ABOUT UNAM

Bilkent University UNAM, knowing the critical leading role of serving as a ‘National Lab’ at Bilkent, strives to create success impact and cross the boundaries of our campus by generating quality knowledge and task force leading to added value and positive progress that are beneficial to our Humankind and Mother Earth.

Bilkent UNAM aims at achieving excellence in science and technology. Standing still is not an option for sustainable and scalable excellence and progress. UNAM always has to advance and be internationally competitive. For that reason, Bilkent UNAM has to push forward and expand excellence as the basis for a leading national lab model.
imagine. think. work. challenge. inspire.

UNAM is supported under Law no. 6550. UNAM would like to thank:
-
Ministry of Industry and Technology, Ministry of Education,
Presidency of Strategy and Budget,
Board of Education and Teaching Policies,
Board of Science, Technology and Innovation Policies,
Council of Higher Education, and
The Scientific And Technological Research Council Of Turkey
for this support.

smile.
UNAM MISSION

Our Mission at UNAM, standing on the edge of knowledge and for global competitiveness, is to achieve **excellence** in nanoscience-nanotechnology, materials science and engineering, and all related fields through:

01. **Generating high-impact, new knowledge to be transformed into societal and economic benefits**

02. **Training qualified human resources to grow into leaders of the future and**

03. **Developing value-added high-tech platforms and advanced R&D capability and competency**

At UNAM, our Motto is thus:

**Excellence in Science and Technology**
UNAM VISION

In line with UNAM Mission, our Grand Vision consists of:

01
- Lead world-class science-technology center and knowledge community
- Pioneer competent infrastructure sustainable at world standards
- Spearhead globally successful ‘national lab’ model and human-centered, institutionalized and professional management

02
- Groom academic and technical leaders of the future
- Foster graduate education and cutting-edge R&D at Bilkent University Institute of Materials Science and Nanotechnology (MSN), attract talents, and train qualified R&D workforce
- Promote technical hands-on trainings of advanced techniques using infrastructure

03
- Shape future R&D via generating creative ideas and quality knowledge in nanoscience-nanotechnology, materials science and engineering, and all related fields
- Leave marks in R&D landscape by transforming ideas and knowledge into societal and economic benefits
- Flourish high-tech ecosystem and ensure the success and continuity of UNAM enterprise with systematic innovation
UNAM MODEL
AS A ‘NATIONAL LAB’
TODAY'S UNAM

Executive Summary

Bilkent University UNAM, established as a ‘National Lab’ at Bilkent, promotes scientific and technological excellence globally in the fields of nanoscience and nanotechnology covering various disciplines of materials science and engineering, electrical and electronics engineering, mechanical engineering, physics, chemistry, and molecular biology, among others.

Our distinguished faculty (over 45 faculty members) and world-class research infrastructure boasting 'open lab' concept (over 400 instruments) provide a vibrant R&D environment in a transdisciplinary ecosystem for approximately 400 researchers and staff to deliver top-tier scientific research work. UNAM faculty have been generously recognized by numerous prestigious awards, grants, and honors, including ERC (European Research Council), and NIH (US National Institute of Health) programs, national academy memberships, and numerous top national and international science awards.

As a metric of quality, according to the Nature Index journal publications, Bilkent UNAM ranks no. 1 as a Research Institute in the country, accumulatively contributing to approximately 7.2% of Turkey’s entire Nature Index journal publications to date.

UNAM infrastructure @Bilkent has been selected for a special large-scale program under Law no. 6550 Research Infrastructure Support with over 100 Million TL of investment and operational budget. With this support, Bilkent UNAM functions as a national lab serving currently over 1,500 users from industry (97 companies) and academia (107 universities). Also, UNAM has contributed to success stories in high-tech commercialization activities (23 spin-offs, 96 patents).

In addition to its intense and successful R&D programs, UNAM is also dedicated to training high-caliber graduate researchers in Material Science and Nanotechnology (MSN) Graduate Program of Bilkent University. Today Bilkent UNAM graduate alumni are highly sought after in R&D landscape.

UNAM is continuously growing the bodies of graduate and post-doc researchers and scientists and attracting talents in nanotechnology and all related fields from national and international institutions using competitive support programs aiming to reverse brain drain, including UNAM Bilkent University Presidential PhD/MS Fellowships and SANCAR Postdoctoral Fellowships.

UNAM Director’s Office
UNAM Governance counts on an independent Board that consists of prominent members.
There exists a never-ending transnational competition of knowledge. Whatever we do, or do not do, the questions remain: Where do we stand now? And where shall our next generations continuously be in this competition?

Bilkent UNAM stands out as an excellence peak of knowledge in this country and the region and is connected via super highways to many peaks of excellence around the globe. To serve this purpose as a National Lab, Bilkent UNAM should and will continue generating cutting-edge knowledge and developing pioneering technologies, and grooming leaders of the future.

To this end, UNAM’s mission and vision are clearly outlined in universal values along with the action steps essential to achieving them. In this journey, the most critical assets for accomplishing these strategic goals are our People and the value we give to them.

In this journey, for their continuous support to reach our strategic goals, We gratefully acknowledge Turkish Republic Ministry of Industry and Technology, Ministry of Education, Presidency of Strategy and Budget, Board of Education and Teaching Policies, Board of Science, Technology and Innovation Policies, Council of Higher Education, and The Scientific And Technological Research Council Of Turkey Also, we bestow our deepest thanks to our Board of governance members for their visionary contributions as our institutional pillars and all of our colleagues ans students who have made critical concibutions towards the direction of excellence in science and technology.

Professor Hilmi Volkan Demir
Chair of UNAM Executive Board
Director
## Contents

<table>
<thead>
<tr>
<th>Page</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>UNAM by Numbers</td>
</tr>
<tr>
<td>20</td>
<td>UNAM Buildings</td>
</tr>
<tr>
<td>23</td>
<td>UNAM Director’s Office</td>
</tr>
<tr>
<td>24</td>
<td>UNAM Support Team and Operation Team</td>
</tr>
<tr>
<td>26</td>
<td>Views about UNAM</td>
</tr>
<tr>
<td>32</td>
<td>Prizes &amp; Awards</td>
</tr>
<tr>
<td>38</td>
<td>UNAM Infrastructure</td>
</tr>
<tr>
<td>44</td>
<td>UNAM Spin-offs</td>
</tr>
<tr>
<td>46</td>
<td>UNAM Patents</td>
</tr>
<tr>
<td>48</td>
<td>Users across Academia &amp; Industry</td>
</tr>
<tr>
<td>51</td>
<td>Partnerships with Industry</td>
</tr>
<tr>
<td>54</td>
<td>Nature Index/High-Impact Publications</td>
</tr>
<tr>
<td>58</td>
<td>Text Book Published by UNAM</td>
</tr>
<tr>
<td>60</td>
<td>MSN Graduate Program and Alumni</td>
</tr>
<tr>
<td>66</td>
<td>NanoDay 2019</td>
</tr>
<tr>
<td>70</td>
<td>UNAM Nanocolloquium 2019</td>
</tr>
<tr>
<td>72</td>
<td>UNAM Principle Investigators</td>
</tr>
<tr>
<td>78</td>
<td>Research Group Highlights</td>
</tr>
<tr>
<td>140</td>
<td>SCI Journal Publications</td>
</tr>
</tbody>
</table>
UNAM by Numbers

01
10,464 m²

02
87 LABORATORIES

03
132 AWARDS
62 NATIONAL
70 INTERNATIONAL

07
96 GRANTED PATENTS
213 PATENT APPLICATIONS
IN THE PROCESS

08
421 RESEARCHERS
AND STAFF

09
OVER 1,500 USERS
UNAM by Numbers

- 04 500 THESES COMPLETED at UNAM
- 05 248 R&D PROJECTS 7 ERC PROJECTS
- 06 23 STARTUPS
- 10 1,400 SCI PUBLICATIONS
- 11 251 NATURE INDEX JOURNAL PAPERS (No.1 in Turkey as a National Lab)
- 12 156 JOURNAL PAPERS with IMPACT FACTOR > 10
**UNAM by Numbers**

**GRADUATE STUDENTS**
**TOTAL 205**
- **MSN**
  - PhD - 37
  - MS - 37
- **OTHER DEPARTMENTS**
  - PhD - 33
  - MS - 56
  - BS - 42

**NUMBER OF COMPLETED THESES**
**TOTAL 501**
- **PhD**
  - 126
- **MS**
  - 375
- **MSN**
  - PhD - 64
  - MS - 133
- **OTHER DEPARTMENTS**
  - PhD - 62
  - MS - 242
UNAM by Numbers

**RESEARCHERS WITH PhD**
- UNAM PIs: 48
- Post-doc Researchers: 101
- Visiting Researchers: 27
- **TOTAL 176**

**ADMINISTRATIVE AND TECHNICAL SUPPORT**
- Administrative staff: 7
- Engineers: 13
- Technicians: 21
- **TOTAL 41**
TOTAL JOURNAL PUBLICATIONS
1,427

2 8 31 66 106 181 280 413 588 742 899 1,079 1,249 1,427

H-INDEX 86

Average citations per paper 24.66
UNAM by Numbers

SUM OF TIMES CITED

38,621

Without self citations
27,301
UNAM supports a wide range of scientific research and technological development in two buildings (UNAM Main Building and UNAM ARL Building) plus a separate laboratory (High-Precision Manufacturing Laboratory), with over 400 instruments, 87 laboratories and two separate cleanrooms of 856 m², covering a total space of 10,464 m².

The UNAM Main Building has been organized to provide different core capabilities on different floors.

<table>
<thead>
<tr>
<th>Floor</th>
<th>Research Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>05</td>
<td>Life Sciences</td>
</tr>
<tr>
<td>04</td>
<td>Nanochemistry</td>
</tr>
<tr>
<td>03</td>
<td>Nanomaterials, Nanodevices</td>
</tr>
<tr>
<td>02</td>
<td>Nanophotonics, Nanoelectronics, Nanomechanics</td>
</tr>
<tr>
<td>01</td>
<td>Laser and Spectroscopy</td>
</tr>
<tr>
<td>G</td>
<td>Nanofabrication, Microfabrication (Cleanroom)</td>
</tr>
<tr>
<td>B</td>
<td>Nanoimaging, Nanofabrication &amp; Characterization</td>
</tr>
</tbody>
</table>
As a National Lab, UNAM is continuously growing and reaching out to more scientists and researchers every year. This growth reflects itself in the scientific outputs and technological outcomes of our center.

UNAM facility has been utilized by more than **1,500 users** in total, with **354 group users** and **1,151 hour-rated users**. As the numbers of UNAM researchers and projects are increasing, UNAM is becoming a central hub for high-impact research and talent attraction.
DIRECTOR’S OFFICE

The UNAM Directorate carries out activities related to coordinating and running administrative and academic operations, keeping the infrastructure working and up-to-date, facilitating scientific research and technological development, initiating collaborations with academia and industry, ensuring financial sustainability, managing human resources, and creating and implementing strategies.
UNAM Support Team

DUYGU BERBEROĞLU
Industry Cooperation and Technopreneurship

FATİH BÜKER
Safety, Maintenance

MURAT DERE
Facility

MUSTAFA DOĞAN
Information Technologies

METE DUMAN
Graphic Design

FUNDÂ EKER
Procurement

MUHAMMED EMİN GÜRBAY
Maintenance

DUYGU KAZANCI
Administration

UMUT SİNANOĞLU
Accounting

AYŞEGÜL TORUN
Human Resources, MSN Graduate Program

OLCAY ÜNDAL
Finance

SONGÜL ZEYBEK
Finance
UNAM Operation Team

SEMİH BOZKURT
Engineer

İSA MURAT ÇALIK
Engineer

GÖKÇE ÇELİK
Team Leader

ZEYNEP ERDOĞAN
Team Leader

MUSTAFA GÜLER
Team Leader

MURAT GÜRE
Team Leader

ABDULLAH KAFADENK
Technical Specialist

ENVER KAHVECİ
Team Leader

ESRA ARMAN KARAASLAN
Engineer

ÖVÜNÇ KARAKURT
Engineer

ERGÜN KARAMAN
Technician

MUSTAFA ÖZER
Technician

FİKRET PİRİ
Technician

ZEHRA VELİ
Engineer
Views about UNAM
Views about UNAM

“... The ‘Optimal of Turkey’ requires the improvement of very comprehensive and multi dimensional strategies in science, culture, education, technologies, economy, political will, ethics and value systems. The nanoscience and nanotechnology contribution will be to move to the upper strata, the socio-economic trends as a very important subset and be a catalyst in the system by providing multifactorial, multisectorial productivity and value added increase. The National Nanotechnology Research Center – UNAM takes place on the upper strata of this search in converging to the ‘Optimal of Turkey’ and to the highest international science targets...”

Dr. Orhan Güvenen, Professor
Bilkent University and UNAM

“... During my PhD study I have visited and collaborated with numerous research labs around the world, from South Korea to Singapore, Germany to USA. I have always felt very proud to say that among all these institutes that I have been to, UNAM is definitely one of the best. UNAM’s world-class research infrastructure and facilities within a single building make it an extremely productive environment for the researchers from various backgrounds to do cutting-edge research. At UNAM, researchers can synthesize new materials, study their emerging physical, chemical and biological properties and also fabricate prototype devices based on these nanomaterials without leaving the building. Therefore, UNAM fosters scientific excellence and empowers its researchers to become world-leading experts. Overall, I feel very grateful for all resources UNAM provides...”

Dr. Burak Güzeltürk, Bilkent University EE PhD and UNAM’16
Currently, Postdoctoral Researcher at Stanford University
CA, USA
"... I completed my doctoral studies at UNAM within the scope of Materials Science and Nanotechnology program between 2012-2017. During this time I had the opportunity to work with researchers from different disciplines and carry out all my scientific ideas. I feel very lucky to be a member of an institute which has been recognized and followed by many researchers all over the world. I would like to thank UNAM for offering me this opportunity..."

**Dr. Melike Sever**, Bilkent University MSN PhD and UNAM’17
Currently, Postdoctoral Researcher at Hacettepe University

"... I was very interested in the high-impact work done at UNAM, both experimentally and theoretically, in various areas of physics, chemistry, and materials science. I was particularly impressed by the work done in the areas of computational materials science, advanced optics and optoelectronics, and the theory and practice of self-assembly and soft materials. I see many areas of common interest with Weizmann Institute scientists and look forward to future collaborations..."

**Dr. Leeor Kronik**, Professor
Weizmann Institute of Science
Israel

"... During my PhD, I had the opportunity to access the unique intellectual ecosystem and experimental infrastructure of UNAM. Together with the world-class research facilities, a transdisciplinary research environment of UNAM has provided us with tremendous opportunities to conduct cutting-edge research and become well-trained scientists by acquiring a significant level of new knowledge and technical/scientific skills and broadening our horizon. Therefore, I feel very lucky to be a graduate of UNAM..."

**Dr. Yusuf Keleştemur**, Bilkent University MSN PhD and UNAM’17
Currently, Postdoctoral Researcher at ETH Zürich
Switzerland
Views about UNAM

“... I am impressed by the achievements of UNAM Nanotechnology Research Centre of the Bilkent University. UNAM has strong faculty and a lot of enthusiastic young students and postdocs working at the forefront of nanotechnology research...”

Dr. Andrey L. Rogach, Professor
ACS Nano Editor
City University of Hong Kong
Hong Kong

“... During my PhD I had the opportunity to access to the world-class research facilities of UNAM. The friendly working environment as well as the rich research equipment helped us to pursue high-quality research. While working at the University of Cambridge, I can clearly see that we –the graduates of UNAM– are capable of conducting world-class research and competing with the leading research institutes of the world since we have all the necessary training, talent, and self-confidence that are needed. Therefore, I fell very lucky to be a scientist who has been trained at UNAM...”

Dr. Talha Erdem, Bilkent University EE PhD and UNAM’16
Currently, Postdoctoral Researcher at University of Cambridge
UK

“... It is my great pleasure to report that UNAM today represents a very nice assembly of young and very active researchers with pronounced leadership and intuition on innovation, they keep on very creative and friendly atmosphere with high research grade and strong technology-oriented spirit. No doubt, we shall witness new achievements from UNAM in the future!...”

Dr. Sergey Gaponenko, Professor
Scientific Director of the Nanophotonics Center
Stepanov Institute of Physics, Member of National Academy of Sciences of Belarus
Belarus
Views about **UNAM**

"... The richness of the scientific environment at UNAM offers an unparalleled opportunity for PhD candidates. If your main area of study transcends the classical definitions of physics, chemistry and biology, UNAM is your place to study. UNAM promotes a rich social environment for early career scientists, opening new avenues for collaborative research. The level of research at UNAM is competitive with the other world class research institutions..."

*Dr. Tolga Tarkan Ölmez*, Bilkent University MSN PhD and UNAM’17, Currently, Postdoctoral Associate at Yale University CT, USA

"...UNAM provides a multidisciplinary and dynamic work place. Students are allowed to use instruments on their own. Therefore, I have gained lots of experience on almost any characterization equipment located at UNAM during my PhD. Today, Nanodev Scientific, which I founded as a spin-off from UNAM, manufactures high-tech optical characterization tools and instruments and I am using my wonderful experience and training at UNAM to guarantee the quality of our products..."

*Dr. Okan Önder Ekiz*, Bilkent University MSN PhD and UNAM’15
Founder and CEO of Nanodev Scientific

"... I was very impressed by the high-level of commitment, which requires considerable investment in research infrastructure and in maintaining these expensive research resources. I was very pleased to hear that students training and research is based on hands-on experience, which is not always the case elsewhere. I was also very pleased to hear that UNAM researchers are deeply involved in international collaborations. I was also very delighted to hear of the successful participation of UNAM researchers in the highly competitive Horizon 2020 EU research program, and most particularly in the prestigious ERC grants..."

*Dr. Reshef Tenne*, Professor (Emeritus)
Weizmann Institute, Member of the Israeli Academy of Sciences and Humanities Israel
Views about UNAM

"... I worked as a PhD student and postdoctoral researcher from 2012 to 2017 at UNAM. It was a privilege to be part of such a pioneering research institute with world-class staff, facilities and infrastructures. In my opinion, UNAM does not only provide scientific environment for ground-breaking research but also opens new doors for young researches to develop new scientist ideas and integrate with international scientific society. I hope UNAM will keep growing with new achievements..."

**Dr. Mohammad Aref Khalily**, Bilkent University MSN PhD and UNAM’17
Currently Postdoctoral Researcher at MESA+ Institute for Nanotechnology, Twente University
Netherlands

"... I found the UNAM institute impressive and highly talented. The staff is of the highest caliber in technology and research abilities and the research work that takes place at UNAM is inspiring and of revolutionary and pioneering nature. Ankara is blessed to have the UNAM Institute on its premises and the population in the region are very lucky to have the opportunity to get educated there...

**Rafi Nave**, The Bronica Entrepreneurship Center Former Director
The Samuel Neaman Institute, Technion
Israel

"... I obtained different academic perspectives, in addition to my biology background, with the variety of courses offered in UNAM and the opportunity to be in contact with all research groups of diverse expertise at UNAM..."

**Dr. Canan Kurşungöz**, Bilkent University MSN PhD and UNAM’17
Prizes & Awards

[Angewandte Chemie (cover), DOI: 10.1002/anie.202000872].
Hilmi Volkan Demir named a Fellow of The Optical Society

Prof. Hilmi Volkan Demir, director of UNAM – The National Nanotechnology Research Centre of Turkey and Bilkent’s Institute of Materials Science and Nanotechnology and a member of the Departments of Electrical and Electronics Engineering and Physics, was elected a Fellow of The Optical Society (OSA) by the society’s board on September 16, during the OSA’s annual meeting in Washington, DC.

The OSA’s mission is “to promote the generation, application and archiving of knowledge in optics and photonics and to disseminate this knowledge worldwide.” The society, founded in 1916, describes itself as “the world’s leading champion for optics and photonics, uniting and educating scientists, engineers, educators, technicians and business leaders worldwide to foster and promote technical and professional development.

"Prof. Demir’s election to Fellow status recognizes his distinct and significant contributions to the advancement of optics and photonics, in particular for pioneering and sustained contributions to the research and development of semiconductor nanocrystal optoelectronics and nanophotonics. Several factors are considered for election including specific scientific and technological contributions, a record of significant publications and patents, technical and industry leadership in the field as well as service to the society and the global optics community.

The number of OSA fellows elected each year is less than 0.5 per cent of the current membership total, making the process both highly selective and competitive. The 2020 class of Fellows will be honored at OSA conferences and meetings throughout 2020.
Serim İlday received ERC Grant

Prof. Serim İlday of UNAM is awarded European Research Council (ERC) Starting Grant to support her research in the field of condensed matter physics. She has been granted EUR 1,5 million over the next five years to explore complexity of dynamic adaptive systems.

She will be using the EU funds to address a profoundly fundamental question at the interface between condensed matter and statistical physics: "When a dynamic adaptive system is faced with multiple choices, which one will it choose? and why?"

She will scrutinize this question using a state-of-the-art colloidal system that she and her coworkers developed in 2017. The system allowed observation of first dynamic adaptive colloidal crystals with a plethora of complex patterns and behavior. Using the ERC funding, Prof. İlday and her team will draw the “fitness landscape” of these crystals to understand and control emergent phenomena far from equilibrium.

Çağlar Elbüken received the BAGEP 2019 award

The results of the Science Academy’s Young Scientist Awards Program (BAGEP) for 2019 were announced. UNAM faculty member who continues his successful work at Bilkent University UNAM, Çağlar Elbüken, has received the BAGEP award.

The BAGEP award aims the determination of the best young academicians to be rewarded and supported for their new research. The BAGEP award, initiated by the Academy of Sciences and funded from the community by public funding, has been given to 243 successful young scientists since 2013.
Onur Tokel received the Mustafa Parlar Research Incentive Award

Each year, the Middle East Technical University Prof. Dr. Mustafa Parlar Foundation recognises scientists from a variety of fields for their exceptional research, in honour of the late METU professor Mustafa Parlar. This year, UNAM and Physics Faculty member, Asst. Prof. Onur Tokel has received the Mustafa Parlar Research Incentive Award, for his contributions to laser material interactions and for developing novel laser lithography approaches.
UNAM’s Team “UNAMBG” won Gold Medal

As in previous years, our university was represented at the 2019 iGEM International Genetically Engineered Machine Competition by a team of students competing under the name Bilkent UNAMBG. The annual synthetic biology contest is held by the nonprofit iGEM Foundation in the city of Boston in the US; this year’s iteration attracted 360 teams from all over the world. Upon completion of the competition, it was announced that Bilkent UNAMBG was one of the teams to receive a gold medal for their project.

Competitors were required to propose a genetic engineering project that included a mathematical modeling segment. The Bilkent team proposed to build a probiotic bacterium that would be able to secrete molecules of insulin, the natural protein that is insufficient in people suffering from diabetes. They called their project PRISMO (for probiotic insulin-secreting modified organism).

In explaining the potential of the PRISMO concept, the team noted that given the increasing number of individuals in the population who have become diabetic, providing a new way to deliver insulin would be a significant advance. Having the option of taking pills containing PRISMO would allow diabetes patients to avoid the need for frequent insulin injections.

In order to receive the coveted gold-medal ranking, projects had to meet certain criteria. These included whether or not the project was completed, the quality of the results and the presence of a mathematical modeling segment.

Bilkent UNAMBG team members for 2019 were Doğuş Akboğa, Ali Göktuğ Attar, Mehmet Emin Bakar, Merve Nida Baştürk, Aysenur Deniz Çayırtepe, Ömer Can Ergül, Elif Zeynep Gülcü, Ahmet Hınçer, Mehmet Ali Hoşkan and İlayda Şenyüz.

Praising the team for their efforts and award-winning achievement, the leader of UNAM’s Synthetic Biosystems Laboratory, Asst. Prof. Urartu Özgür Şafak Şeker, pointed to the fact that the students worked hard to complete their project within the span of approximately eight months, while at the same time keeping up with the demands of their course load. He noted that only one-third of the teams participating in the 2019 iGEM competition received gold medals, with teams from some of the world’s top universities among the two-thirds receiving lower rankings.

Looking forward to next year’s iGEM competition and beyond, Bilkent UNAMBG is seeking new team members from a wide range of fields (including engineering, mathematics, physics and the social sciences as well as biology) to contribute to further achievements. Students who are interested are invited to email the team at unambbigem@gmail.com.
Prizes & Awards

Sila Köse (MSN) won Early Carrer Researcher Talk Award at the Designer Biology 2019 Conference

Sila Köse won the Early Carrer Researcher Talk Award at the Designer Biology 2019 Conference for her oral presentation entitled “Cellular Biosensors with Engineered Genetic Logic Gates for Biomedical Applications.” The conference was organized in Newcastle, UK (31 July-2 August 2019). Designer Biology 2019 conference series are being organized bi-yearly. The conference aims to bring scientists together from the fields of synthetic biology, genetic engineering and protein engineering.
UNAM Infrastructure

UNAM Main Building has been designed to provide a multidisciplinary research environment for researchers from various disciplines. In 2019, UNAM infrastructure was expanded with the addition of ARL Building (Advanced Research Lab) and high-precision manufacturing laboratory of Mechanical Engineering. Since the establishment of UNAM, the infrastructure has been sustained and improved to address the needs of researchers from academia and industry. Today UNAM houses altogether over 400 instruments.

With its ever-expanding capabilities, UNAM is being run using state-of-the-art lab management platform and coordination to support its research and development activities. As a result, UNAM has achieved over 95% up-and-running time for its core facility instruments, which can be accessed by its authorized users 24/7. Equally important, UNAM’s specialized instruments can be utilized under the guidance of highly qualified UNAM technical team, if desired. New users can also be accompanied by experienced UNAM personnel to make the most of their time at UNAM facilities.

UNAM infrastructure is regularly updated to satisfy the needs of its researchers. The details of each instrument can be viewed on our facility web page: [http://www.unam.bilkent.edu.tr/facility/](http://www.unam.bilkent.edu.tr/facility/)

UNAM information system, **UNAM-IS**, is used as a one-stop address to obtain access to all equipment. Users first sign up to receive their username and password on UNAM-IS. After defining their projects, they can access the listed equipment. UNAM users can also coordinate hands-on trainings on instruments and keep track of the status of each equipment on UNAM-IS.

UNAM-IS reservation procedure is hassle-free. The authorized users can monitor the availability of each instrument and make a reservation from their UNAM-IS portal.
**IMAGING / MICROSCOPY**
- Atomic Force Microscope (AFM, PSIA)
- Atomic Force Microscope (AFM, Asylum)
- Confocal Microscope
- Dual Beam
- E-Beam Lithography (E-BEAM)
- Environmental Scanning Electron Microscope (ESEM)
- Fluorescent and DIC Equipped Upright Microscope
- Fluorescent and DIC Equipped Inverted Microscope
- Material Microscopes
- SNOM + Raman Microscope
- Stereomicroscope
- Transmission Electron Microscope (TEM)

**SPECTROSCOPY / CHROMATOGRAPHY**
- Accurate-Mass Quadrupole Time-of-Flight (Q-TOF) LC/MS
- CHNS/O Elemental Analyzer
- Circular Dichroism System (CD)
- Fluorescence Spectrophotometer
- FTIR Spectrometer (Tensor 37)
- FTIR Spectrometer with Microscope (Nicolet 6700)
- FTIR Spectrometer with Microscope (Vertex 70)
- FT-Raman Spectrometer
- Gas Chromatography Mass Spectrometer (GC/MS)
- Gel Permeation Chromatography (GPC)
- High Resolution Mass Time-of-Flight (TOF) LC/MS
- Inductively Coupled Plasma-Mass Spectrometer (ICP-MS)
- Microplate Reader
- Nuclear Magnetic Resonance Spectrometer (NMR)
- Preparative High Performance Liquid Chromatography
- Size Exclusion Chromatography (SEC)
- Time-resolved Fluorescence
- UV-VIS Spectrophotometer
- UV-VIS-NIR Spectrophotometer
- X-Ray Fluorescence Spectrometer (XRF)
- X-Ray Photoelectron Spectrometer (XPS)
- Peptide Synthesizer Division

**CLEANROOMS**
- Asher
- Atomic Layer Deposition (ALD, Fiji)
- Atomic Layer Deposition (ALD, Savannah)
- Autoclave
- Critical Point Dryer
- Dicing Saw
- Die Bonder
- E-Beam Evaporation
- Electroplating Station
- Inductively Coupled Plasma (GaN, GaAs)
- Inductively Coupled Plasma (Si)
- Low Pressure Chemical Vapor Deposition (LPCVD)
- Mask Aligner
- Mask Writer
- Optical Profilometer
- Organic Thin Film Evaporator
- Plasma Enhanced Chemical Vapor Deposition (PECVD, Plasma-Therm)
- Plasma Enhanced Chemical Vapor Deposition (PECVD, Vaksis)
- Probe Station
- Rapid Thermal Annealing (RTA)
- Scanning Electron Microscope (NanoSEM)
- Semiconductor Parameter Analyzer
- Spinners
- Sputtering Systems
- Thermal Evaporators
- Wet Benches
- Wire Bonders
- XeF2 Etcher
- Reactive Ion Etching (RIE)
- Fine Tech Chip Bonder
UNAM Infrastructure

MATERIAL SYNTHESIS / CHARACTERIZATION
- BET Physisorption-Chemisorption
- Contact Angle Measurement System
- Differential Scanning Calorimetry (DSC, Netsch)
- Differential Scanning Calorimetry (DSC, TA)
- Dynamic Mechanical Analyzer
- Freeze Dryer System
- Isothermal Titration Calorimetry (ITC)
- Materials Research Diffractometer (MRD)
- Micromechanical Tester
- Multi-Purpose X-Ray Diffractometer
- Porosimeter
- Physical Property Measurement System (PPMS)
- Pycnometer
- Rheometer
- Thermal Gravimetric Analysis (TGA)
- Zeta Potential (Zeta Sizer)

OPTICAL / LASERS
- Carbondioxide Lasers (Coherent, Lumenis)
- Ellipsometer (IR-VASE)
- Ellipsometer (V-VASE)
- Femtosecond Laser System
- Fiber Laser (Toptica)
- Fiber Polishing Machine
- FSP Spectrum Analyzer
- He-Cd Laser (Kimmon)
- He-Ne Lasers
- High Power Lasers (custom)
- High Precision Positioning System
- Infrared Camera
- Lock-In Amplifiers
- Monochromators
- Optical Spectrum Analyzers
- Solar Simulator
- Supercontinuum Laser Source
- Tunable Diode Laser (Toptica)
- Tunable Semiconductor Laser (Santec)
- Tunable Telecommunication Laser (Newport)
- UV Lasers
- Xe, Halogen, Deuterium Light Sources

HIGH PRECISION MANUFACTURING
- 5 Axis Machine Nanotech FG 350
- SODICK-Wire EDM
- Zeiss MICURA CMM
- Keyence Microscope
- Zwick Microsurgery Equipment
- 3D Printer Markerbot and Replicator
UNAM Infrastructure

FIBER PRODUCTION / CHARACTERIZATION
- Fiber Draw Tower
- Fiber Draw Tower (high temperature up to 2,300 °C)
- Glass Production System
- Infrared Camera
- Modified Chemical Vapor Deposition (MCVD)
- Preform Analyzer
- Preform Consolidator
- Preform Polariscope
- Preform Slice Measurement System
- Preform Washer
- Quartz Cutting Saw
- Rocking Furnace
- Scrubber
- Thermal Evaporation System
- Three-zone Furnace (1,200 °C)
- Vacuum Ovens

SAMPLE PREPARATION
- Cut-off and Grinding Machine
- Dimple Grinder
- Disc Grinder
- Disc Punch
- Electrolytical Thinner
- Glass KnifeMaker
- Grinding and Polishing Machines
- Mounting Press
- Precision Etching Coating System (PECS)
- Precision Ion Polishing System (PIPS)
- Ultramicrotome
- Ultrasonic Cutter
- Vacuum Impregnation

BIOTECHNOLOGY
- Bioreactors (2 L / 5 L / 30 L)
- Centrigures / Microfuges / Ultracentrifuges
- Cold Room
- Cryostat
- Electroporator
- -80°C Freezers
- Gel Imaging and Documentation System
- Gradient PCR
- Gradient Real-Time PCR
- Laminar Flow Cabinets
- Microplate Reader
- Microtomes
- Osmometer
- Shaking Incubators
- Sterile Cabins
- Vibratome
There are various evaporation methods we use at UNAM to deposit nanometer thick coatings of metals and dielectrics on surfaces. A user monitors the chamber of the electron beam evaporator at UNAM in the picture.
As being the first and only national nanotechnology lab of Turkey, UNAM is actively engaged in technologies that have high market value. The technological leaps discovered by UNAM researchers have been the seed for several UNAM spin-off companies.

The companies benefit from the close proximity of incubation centers such as Bilkent Cyberpark, METU Technopolis and Hacettepe Technopolis which provide them with the collaborative ecosystem to expedite the product realization cycle. Our spin-offs have benefited an additional boost with the establishment of Bilkent University Technology Transfer Office. Some of UNAM spin-off companies include:

- Auron Teknoloji
- Biyonesil
- CSY
- Deber
- E-A Teknoloji
- Innovative In Vivo Sensing
- İnovel
- İnovnano
- IPS
- LST Scientific Instruments
- MRid
- Nanobiyoteknoloji
- Nanodev
- NanoEye
- Nanosens
- Niser Yazı
- SY Nanoboyatek
- Synbiotik
- Yeni Bilge Nanoteknoloji
E-A Teknoloji

E-A Teknoloji Ltd. is an UNAM spin-off company established in 2010. E-A Teknoloji enjoys its success in producing and marketing medical optical fibers for endovenous laser operations. Optical fibers have long been used in treatment of varicose veins, which were produced in European countries. After several years of R&D, an essential part of which took place at UNAM laboratories, now the know-how of medical optical fiber production for endovenous applications is accomplished. Among different types of optical fibers used in laser applications, especially radial emitters, of which output is in the shape of a homogenous ring towards the circumference of the fiber, are frequently used by the medical practitioners for their enhanced efficiency in the treatment.

The radial fibers developed by E-A Teknoloji have passed all the tests necessary for the field use. Currently the serial production and marketing of these “Made in Turkey” radial fibers have been initiated, which is a huge leap for the company from doing solely R&D, towards large-scale manufacturing. The very first feedbacks from the medical doctors that used these fibers are very motivating because they have better efficiency and durability compared to their available products in the market. Yet, the scope of the company is not limited neither to endovenous applications nor radial fibers, continuing research on other types of optical fibers, which would find applications in various fields such as urology, gynecology, ENT operations, ophthalmology and other minimally invasive and non-invasive laser applications.

Nanodev Scientific

Nanodev Scientific is a spin-off company that manufactures advanced optical and biomedical characterization devices. Nanodev has revenue on a wide range of high-tech products including surface plasmon resonance systems, biomedical detection systems and advanced microscopes. Currently, Nanodev Scientific devices are being used at leading institutions worldwide. Novel projects of Nanodev were awarded several times including “Most-Promising Start-up”, “Novel Biomedical Device” and “1st prize in R&D Contest”. Main goal of Nanodev is to apply their cutting-edge technology into daily life.

The most promising project of Nanodev is a device that makes it possible to detect a series of diseases at home. Imagine being able to touch a small device and instantly get back whether you have key indicators for a heart attack or an infectious disease. Such early detection tools are some of the innovative products that Nanodev is developing.
<table>
<thead>
<tr>
<th>PATENT NUMBER</th>
<th>APPLICATION DATE</th>
<th>PUBLICATION DATE</th>
<th>TITLE</th>
<th>INTERNATIONAL PATENT FAMILY</th>
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<td>2015/16832</td>
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<td>Bir optik fiber taşıyıcı elde etme yöntemi</td>
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<td>2015/16373</td>
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<td>2015/14661</td>
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<td>2014/00221</td>
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<td>2019/19978</td>
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<td>2019/20220</td>
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<td>Kılif ışın sıyırıcı ve üretim yöntemi</td>
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</table>
UNAM Users across Turkey

Are you after a challenging research problem? Do you need help in performing experimental measurements using state-of-the-art equipment? Then, UNAM is the place for you.

Since its establishment, UNAM has been serving many hundreds of researchers from various disciplines. We believe sharing the expertise we have is the key to leapfrog revolutionary technologies. We place utmost priority in keeping the infrastructure functional for the use of all our users.

UNAM is accessible to all researchers. Currently there are more than 1,500 users of UNAM. Being located in Ankara, UNAM is accessible to all researchers across Turkey. The number of universities that are utilizing UNAM has reached 107 and the number of companies using UNAM is now 97. We receive very positive feedback from all UNAM users and this motivates us further in extending our facility and serving the whole community more effectively.

At UNAM, our users are fully engaged in all the steps of the service UNAM provides. It is not only the infrastructure, but also our expertise we share that help users make the most out of their experience at UNAM. We continuously strive to improve our technical capability and operation procedures to maximize the output of all UNAM users.
UNAM Users from Academia

Abdullah Gül University, Kayseri
Acıbadem University, İstanbul
Adana Araştırma University, Adana
Afyon Kocatepe University, Afyon
Akdeniz University, Antalya
Aksaray University, Aksaray
Amasya University, Amasya
Anadolu University, Eskişehir
Ankara Hacibeyrami Veli University, Ankara
Ankara University, Ankara
Antalya Bilim University, Antalya
Ardahan University, Ardahan
Atatürk University, Erzurum
Atılım University, Ankara
Aydın Adnan Menderes University, Aydın
Balıkesir University, Balıkesir
Başkent University, Ankara
Beykent University, İstanbul
Bilecik Şeyh Edebali University, Bilecik
Bingöl University, Bingöl
Boğaziçi University, İstanbul
Bolu Abant İzzet Baysal University, Bolu
Burdur Mehmet Akif Ersoy University, Burdur
Bursa Uludağ University, Bursa
Bursa Teknik University, Bursa
Çankaya University, Ankara
Çankırı Karatekin University, Çankırı
Çukurova University, Adana
Dicle University, Diyarbakır
Doğu Akdeniz University, KKTC
Dokuz Eylül University, İzmir
Düzece University, Düzce
Ege University, İzmir
Erciyes University, Kayseri
Erzincan Binali Yıldırım University, Erzincan
Erzurum Technical University, Erzurum
Eskişehir Teknik University, Eskişehir
Fırat University, Elazığ
Gazi University, Ankara
Gaziantep University, Gaziantep
Gezbe Teknik University, Kocaeli
Giresun University, Giresun
Gümüşhane University, Gümüşhane
Hacettepe University, Ankara
Harran University, Şanlıurfa
Hatay Mustafa Kemal University, Hatay
Hitit University, Çorum
İhsan Doğramacı Bilkent University, Ankara
İnönü University, Malatya
İstanbul Sebahattin Zaim University, İstanbul
İstanbul Medeniyet University, İstanbul
İstanbul Teknik University, İstanbul
İstanbul University, Istanbul
İzmir Katip Çelebi University, İzmir
İzmir Yüksek Teknoloji Enstitüsü, İzmir
Kadir Has University, İstanbul
Kafkas University, Kars
Kahramanmaraş Sütçü İmam University, K.Marash
Karabük University, Karabük
Karadeniz Teknik University, Trabzon
Karamanoğlu Mehmet Bey University, Karaman
Kastamonu University, Kastamonu
Kırikkale University, Kırıkkale
Kırıkkale University, Kırıkkale
Kırşehir Ahı Evran University, Kırşehir
Koç University, İstanbul
Kocaeli University, Kocaeli
Konya Gıda ve Tarım University, Konya
Konya University, Konya
KTO Karatay University, Konya
Kütahya Dumlupınar University, Kütahya
Malatya Turgut Özal University, Malatya
Maltepe University, İstanbul
Manisa Celal Bayar University, Manisa
Marmara University, İstanbul
Mersin University, Mersin
Millet Savunma University, İstanbul
Muğla Sitki Koçman University, Muğla
Necmettin Erbakan University, Konya
Neşehir Hacı Bektaş Veli University, Neşehir
Niğde Omer Halisdemir University, Niğde
Nişantaşı University, İstanbul
Ondokuz Mayıs University, Samsun
Ordu University, Ordu
Orta Doğu Teknik University (ODTÜ), Ankara
Osmangazi University, Eskişehir
Osmaniye Korkut Ata University, Osmaniye
Pamukkale University, Pamukkale
Recep Tayyip Erdoğan University, Rize
Sabancı University, İstanbul
Sağlık Bilimleri University, İstanbul
Sakarya University, Sakarya
Selçuk University, Konya
Sivas Cumhuriyet University, Sivas
Süleyman Demirel University, Isparta
Tekirdağ Namık Kemal University, Tekirdağ
TOBB ETÜ Ekonomi ve Teknoloji University, Ankara
Tokat Gaziosmanpaşa University, Tokat
Trakya University, Edirne
Türk Hava Kurumu University, Ankara
Yakın Doğu University, KKTC
Yeditepe University, İstanbul
Yıldırım Beyazıt University, Ankara
Yıldız Teknik University, İstanbul
Yozgat Bozok University, Yozgat
Yüzyüceil University, Van
Zonguldak Bülent Ecevit University, Zonguldak
Some of companies utilizing UNAM infrastructure include:

AB-MIKRONANO
AGAMİRZE
AKZO NOBEL BOYA
ARÇELİK
ARGETEST
ARITEKS
ART BANT
ARVEN
AS İNŞAAT
ASELSAN
ATABİM BOYA
BAYRAK AR-GE
BEREN ECZA DEPOSU
BETOPAN
BİYOTEX
BOSCH SIEMENS
BOYLAM YAZILIM
BRK MEDİKAL
CANNES
CREON
CYBERPARK
DELTAV UZAY TEKNOLOJİLERİ
DELTAMED
DIGITEST SAV.
DİZAYN GRUP
DROGSAN ECZACILIK
DST MEDİKAL
DYO
E-A TEKNOLOJİ
E-BERK MAKİNA
ECZACIBAŞI
EMBİL İLAÇ
ENİGMA
ERMEKSAN
ETI MADEN
FOTONİKA
GATA
GENAMAR AR-GE
GENZ BIYOTEKNOLOJİ
GO ENERJİ
GODİ BIYOTEKNOLOJİ
HAYAT KİMYA
HEMOSOFİ BİLİŞİM
İBA VALSERA
İKSA LTD.
İNOVAKTİF
İSKO-SANKO
İŞBİR SENTETİK
KORDSA
KORDSA TEKSTİL
KOROZO
MAN
METEKSAN
MIKRÖ BIYOSİSTEMLER
MIKRON MAKİNA
MIKROSİSTEMLER
MIT
MONO KRİSTAL TEKNOLOJİLERİ
MTA
NANODEV
NANOGRAFİ
NORMMED MEDİKAL
NUROL
ÖZTEK TEKSTİL
Paşabahçe
PLASBANT PLASTİK
PMS MEDİKAL
RAMADA
ROKETSAN
SASAN MEDİKAL
SENSES
SERMED TİBBİ ÇİHAZLAR
SİSTEM ALUMİNYUM SANAYİ
SO SOĞUTMA
SPM A.Ş.
STC ELEKTRONİK
ŞİŞECAM
TDU SAVUNMA SUN TESKİTİL
TEKSER
TUSAŞ (TAI)
TURPAMED
TÜBİTAK MAM
TÜBİTAK SAGE
TÜBİTAK UZAY
TÜPRAŞ
TÜRKİYE PETROLLERİ
ULUSOY MEDİKAL
VAKSİS
VAMED MEDİKAL
VESTEL
VIROSENS MEDİKAL
UNAM serves the whole country with its infrastructure; in 2018, the number of the companies using UNAM infrastructure has reached 97. The total number of external users has exceeded 1,500. Since UNAM is used by researchers with a wide range of interests, it creates an efficient ecosystem for other researchers to network with each other.

UNAM offers an environment that promotes industry and academy partnership. Researchers at UNAM conduct interdisciplinary projects and meet the expectations of industry stakeholders. UNAM aims to increase the scientific and technological capacities of SMEs and large institutions by carrying out joint and industry contracted projects. Besides, UNAM’s infrastructure provides companies with access to state-of-the-art equipment and the technical know-how required for their specific needs.

In addition to providing industrial companies with infrastructure support, UNAM also conducts research projects with companies. Currently, various research projects are funded by industrial companies at UNAM. Beyond working one-to-one with the companies, cooperation meetings are also organized within the scope of high-tech platform to bring together a large number of companies and research centers.

Together with the Turkish Aerospace Industry (TUSAŞ), our application to TÜBİTAK 2244 Industry Doctoral Program has been accepted. Doctoral students who will be supported within the scope of the project will have the opportunity to work at TUSAŞ after completing their PhD studies at UNAM.

UNAM signs protocols with the companies that wish to carry out R&D at UNAM. With the application of "CorporateLab@UNAM" which is implemented with these protocols, companies can take part at UNAM as an enterprise. As the first examples, “TUSAŞ@UNAM”, “Vestel@UNAM” and “Şişecam@UNAM” protocols were signed. Some other big companies have expressed their desire to take part at UNAM in the same program. UNAM has thus far also signed protocols with ASELSAN, Cannes Biotechnology and GenZ Biotechnology for training and infrastructure use.
Nature Index / High-Impact Publications


Nature Index/High-Impact Publications


UNAM in Nature Nanotechnology

Engineering students visit a nano centre

Visiting a research centre specialized in nanoscience and nanotechnology can be an inspiration for students in other disciplines, as Chris Tourney explains.

Bilkent University in Ankara, Turkey, is an elite institution that focuses primarily on STEM topics, that is, science, technology, engineering and math. One of its crown jewels is UNAM, which has been a source of pride for all UNAM employees researchers and students to be mentioned in such an article in a magazine that is read worldwide.

The article begins with “Bilkent University in Ankara, Turkey, is an elite institution that focuses primarily on STEM topics, that is, science, technology, engineering and math. One of its crown jewels is UNAM, which (in Turkish) stands for national nanotechnology research centre.”
Selected UNAM Journal Publications Highlighted on the Covers

[Advanced Materials (cover), DOI: 10.1002/adma.202070077].

[Advanced Materials (cover), DOI: 10.1002/adma.202070054].

[Advanced Materials (cover), DOI: 10.1002/adma.201970281].

[ACS Synthetic Biology (cover), DOI: 10.1021/cssynbio.9b00062].

[ACS Synthetic Biology (cover), DOI: 10.1021/cssynbio.9b00291].

[The Journal of Physical Chemistry (cover), DOI: 10.1021/jpcc.9b06925].

[The Journal of Physical Chemistry (cover), DOI: 10.1021/jpcc.9b08707].

[Chem Cat Chem (cover), DOI: 10.1002/cctc.201900144].

[Chem Bio Chem (cover), DOI: 10.1002/cbic.201900400].

[Angewandte Chemie in press, DOI: 10.1002/anie.202000872].
Textbook published by UNAM
Cambridge University Press book on Applied Nanophotonics translated to Chinese

This unique text provides an accessible yet rigorous introduction to the basic principles, technology, and applications of nanophotonics. It explains key physical concepts such as quantum confinement in semiconductors, light confinement in metal and dielectric nanostructures, and wave coupling in nanostructures, and describes how they can be applied in lighting sources, lasers, photonic circuitry, and photovoltaic systems. Readers will gain an intuitive insight into the commercial implementation of nanophotonic components, in both current and potential future devices, as well as challenges facing the field. The fundamentals of semiconductor optics, optical material properties, and light propagation are included, and new and emerging fields such as colloidal photonics, Si-based photonics, nanoplasmonics, and bioinspired photonics are all discussed. This is the ‘go-to’ guide for graduate students and researchers who are interested in nanophotonics, and students taking nanophotonics courses. In 2019, this book was translated into Chinese by the Chinese Academy of Sciences (CAS).

Highlighted in Nature Photonics | VOL 13 | JANUARY 2019 | 5

At UNAM, Materials Science and Nanotechnology (MSN) graduate program offers a vibrant transdisciplinary academic environment at the Bilkent University Institute of Materials Science and Nanotechnology. We are currently offering Master of Science (M.Sc.) and Philosophy of Doctorate (PhD) degrees under MSN program. Currently, MSN program has 31 M.Sc. students and 35 PhD students.

MSN provides the graduate students with a stimulating educational training in materials and nanoscience-nanotechnology. MSN program ensures the graduate students to conduct high-quality scientific research and technological development in the laboratories equipped with the state-of-the-art facilities at UNAM – The National Nanotechnology Research Center covering the areas of the design and synthesis of advanced and nanostructured materials for the health, energy, environment, water, food, communications, and information technologies as well as the emergent and future technologies. This graduate program is designed to train young scientists and researchers who can pursue creative, outstanding R&D in the various fields of nanoscience-nanotechnology and materials science and engineering, including but not limited to nanobiotechnology, nanomedicine, atomic scale imaging, sensing, nanoelectronics, nanophotonics, femtosecond lasers, nanotextile, nanomaterials, nanofibers, nanotribology, hydrogen economy, and solar energy. The program spans from the fundamental to the applied and innovative research and equips the graduate students with the necessary knowledge and cutting-edge skills to grow into scholar and practicing scientists and researchers who will not be afraid to delve into and be able to offer creative solutions to the challenging problems of today and tomorrow our country and the world are facing. The courses to be taken by the MSN graduate students should focus on the subject of their own thesis work.
<table>
<thead>
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<th>CODE</th>
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<tr>
<td>MSN 500</td>
<td>Concepts in Materials Science</td>
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<td>MSN 501</td>
<td>Atomic Structure, Mechanical and Thermal Properties of Materials</td>
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<tr>
<td>MSN 510</td>
<td>Imaging Techniques in Materials Science and Nanotechnology</td>
</tr>
<tr>
<td>MSN 512</td>
<td>Biomedical Materials</td>
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<tr>
<td>MSN 514</td>
<td>Computational Methods for Material Science and Complex Systems</td>
</tr>
<tr>
<td>MSN 517</td>
<td>Nanoscience and Nanotechnology I</td>
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<td>MSN 518</td>
<td>Nanoscience and Nanotechnology II</td>
</tr>
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<td>MSN 519</td>
<td>Applications of Microfluidics and Nanofluidics</td>
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<td>MSN 521</td>
<td>Biotechnology</td>
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<td>Synthetic Biology</td>
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<td>MSN 523</td>
<td>Nanocomposites</td>
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<tr>
<td>MSN 524</td>
<td>Introduction to Mesoscopic Solid-State Materials</td>
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<td>MSN 525</td>
<td>Self-Organized and Self-Assembled Systems From Nanoscience to Biotechnology</td>
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<td>MSN 526</td>
<td>Functional Surfaces and Interfaces</td>
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<tr>
<td>MSN 527</td>
<td>Quantitative Approaches in Biophysics and Life Sciences</td>
</tr>
<tr>
<td>MSN 534</td>
<td>Polymeric Materials</td>
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<td>MSN 541</td>
<td>Nanobiotechnology</td>
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<tr>
<td>MSN 551</td>
<td>Introduction to Micro and Nanofabrication</td>
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<tr>
<td>MSN 555</td>
<td>Laser Physics: from Principles to Applications for Materials Science</td>
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<tr>
<td>MSN 598</td>
<td>Seminar I</td>
</tr>
<tr>
<td>MSN 599</td>
<td>MS Thesis</td>
</tr>
<tr>
<td>MSN 698</td>
<td>Seminar II</td>
</tr>
<tr>
<td>MSN 699</td>
<td>PhD Thesis</td>
</tr>
</tbody>
</table>
We are very proud that our alumni are highly sought after both in academia and industry because of the world-class education and training provided at UNAM.

UNAM graduates either select to pursue their careers at the world’s leading universities or move to the industry to work at high-tech companies.
Some of UNAM MSN alumni and their current positions can be found in the following list:

Adem Yıldırım, Postdoctoral Researcher at University of Colorado
Berna Şentürk, Postdoctoral Researcher at EMPA
Berna Şentürk, Postdoctoral Researcher at EMPA
Bilal Kılıç, Faculty Member at Özyeğin University
Bilge Temiz, Researcher at TUBITAK-SAGE
Bülent Öktem, Lead Laser Design Engineer at ASELSAN
Burcu Gümüşçü Sefunç, Postdoctoral Researcher at UC Berkeley
Büşra Mammadov, Product Manager at Sentegen Biotechnology
Çağla Akgün, Engineer at ASELSAN
Çağla Eren Çimenci, PhD Student at University of Ottawa Heart Institute
Ebru Cihan, PhD Student at Karlsruhe Institute of Technology (KIT)
Egemen Deniz Eren, PhD Student at Technische Universiteit Eindhoven
Elif Ertem, PhD in Material Science and Engineering Intern at MPM at Cambridge
Erol Özgür, Postdoctoral Researcher at University of Arizona
Fatma Kayaci, Specialist at TUBITAK-SAGE
Gökçe Küçükyan Doğu, Process Engineer at Intel Corp.
Gökşu Çınar, Postdoctoral Researcher at KTH Royal Institute of Technology
Gözde Uzunalı, Postdoctoral Researcher at Purdue University
Hakan Ceylan, Postdoctoral Researcher at Max Planck Institute
Handan Acar, Postdoctoral Researcher at University of Chicago
Hasan Şahin, Faculty Member at Izmir Institute of Technology
Hilal Ürün Gülüsüner, Postdoctoral Researcher at Washington University
Hülya Budunoğlu, Project Engineer at ASELSAN
Ilke Şimşek Turan, Principle Researcher at Hayat Kimya R&D
Kıvanç Özgören, General Manager at Fiblas Fiber Lazer San. Tic. Ltd.
Mehmet Kanık, Postdoctoral Researcher at MIT
Mehmet Topsakal, Research Associate at Univ. of Minnesota - Brookhaven National Lab.
Melike Sever, Quality Control Manager at Doku Biyoteknoloji

Mohammad Aref Khalil, Postdoctoral Researcher at University of Twente
Mustafa Beter, PhD Student at University of Eastern Finland
Mutlu Erdoğan, Postdoctoral Researcher at Max Planch Institute
Nurcan Haştar, PhD Student at Freie University
Ökan Öner Elikz, Founder and CEO at Nanodev Mühendislik
Ömer Faruk Sanoğlu, Researcher at E-Kalite
Onur Büyükçakır, Postdoctoral Researcher at University of Kaist
Pelin Tören, Scientist at Joanneum Research
Rashad Mammadov, Postdoctoral Researcher at Virginia University
Ruslan Garifullin, Postdoctoral Researcher at Bilkent Universitesi
Ruslan Guliyev, Postdoctoral Researcher at Rutgers University
Safacan Kölemen, Faculty Member at Koç University
Samet Kocabey, PhD Student at Ludwig Maximilian University of Munich
Seher Yaylacı, Faculty Member at Lokman Helim University
Seren Hamsici, PhD Student at University of Oklahoma
Seydi Yavaş, Founder of Lumos Laser at Boğaziçi University
Seymur Cahangirov, Faculty Member at Bilkent University
Sündüs Erbaş Çakmak, Faculty Member at Konya Food and Agriculture University
Taha Bilal Uyar, Research and Development Manager at Coante Quartz Surfaces
Timur Ashirov, PhD Student at Université de Fribourg
Tolga Tarkan Ölmez, Postdoctoral Researcher at Yale University
Turan Selman Erkal, Postdoctoral Researcher at University College London
Uğur Teğin, PhD Student at Ecole Polytechnique Fédérale de Lausanne
Veli Öngün Özçelik, Postdoctoral Researcher at Princeton University
Yusuf Çakmak, Postdoctoral Researcher at Konya Food and Agriculture University
Yusuf Keleştemur, Postdoctoral Researcher at ETH Zurich
Zeynep Ayaçoğlu, Postdoctoral Researcher at University of Michigan
Laser ablation is frequently used in the industry for materials cutting and drilling processes.
UNAM NanoDay 2019
UNAM NanoDay 2019

UNAM hosted the 7th NanoDay event on 21 March 2019.

The NanoDay event, which has become a traditional annual event, was hosted by UNAM on 21 March 2019. In the 7th NanoDay, world-renowned scientists came together as in the previous years.

In this full-day event, where the latest scientific developments were shared, invited Keynote Speakers Monica Olvera De La Cruz (Nortwestern University), Chris Toumey (South Carolina University), Thomas Hermans (Strasbourg University) presented their works.

NanoDay 2019 Keynote Speakers

MONICA OLVERA DE LA CRUZ
Nortwestern University

CHRIS TOUMEY
South Carolina University

THOMAS HERMANS
Strasbour University
<table>
<thead>
<tr>
<th>Date</th>
<th>Speaker</th>
<th>Affiliation</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 15, 2019</td>
<td>Max von Delius</td>
<td>University of ULM</td>
<td>Self-assembly of adaptive orthoester architectures</td>
</tr>
<tr>
<td>February 22, 2019</td>
<td>Yannick Rondelez</td>
<td>ESPCI</td>
<td>DNA-based networking</td>
</tr>
<tr>
<td>March 1, 2019</td>
<td>Yves Bellouard</td>
<td>Ecole Polytechnique Federale de Lausanne</td>
<td>Femtosecond laser three-dimensional exposure of silica substrate in the non-ablative regime: from laser-induced modifications to applications</td>
</tr>
<tr>
<td>March 8, 2019</td>
<td>Iwan Verzhbitskiy</td>
<td>National University of Singapore</td>
<td>Light-matter interactions in 2D van der Waals semiconductors and their heterostructures</td>
</tr>
<tr>
<td>March 15, 2019</td>
<td>Sebastien Hentz</td>
<td>CEA LETI Technology Research Institute</td>
<td>Large scale integration of nano electro- and optomechanical systems for mass and biological sensing</td>
</tr>
<tr>
<td>March 29, 2019</td>
<td>Satya Majumdar</td>
<td>Universite de Paris-Sud</td>
<td>KPZ story</td>
</tr>
<tr>
<td>April 12, 2019</td>
<td>Sergei K. Turitsyn</td>
<td>Aston Institute of Photonic Tech.</td>
<td>Nonlinear world of commercial photonic systems</td>
</tr>
<tr>
<td>April 26, 2019</td>
<td>Julia Yeomans</td>
<td>University of Oxford and Pauline Chan Fellow at St. Hilda College</td>
<td>Dense active matter</td>
</tr>
<tr>
<td>Date</td>
<td>Speaker</td>
<td>Title</td>
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<tr>
<td>May 10, 2019</td>
<td>Olivier Dauchot</td>
<td>Model experiments of active matter: at the interface between living organisms and theoretical models.</td>
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<tr>
<td>September 25, 2019</td>
<td>Helge Kragh</td>
<td>Spin, relativity and quantum mechanics</td>
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<tr>
<td>October 1, 2019</td>
<td>Brian D. Gerardot</td>
<td>Quantum dots in two-dimensional heterostructures</td>
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<tr>
<td>November 8, 2019</td>
<td>Hakan E. Tureci</td>
<td>Quantum electrodynamics of superconducting circuits</td>
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<tr>
<td>November 15, 2019</td>
<td>Maksym V. Kovalenko</td>
<td>Highly luminescent nanocrystals of cesium and formamidinium lead halide perovskites: from discovery to applications</td>
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<tr>
<td>November 22, 2019</td>
<td>Metin Sitti</td>
<td>Small-scale wireless medical robots</td>
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<tr>
<td>November 29, 2019</td>
<td>Gianfranco Pacchioni</td>
<td>Two-dimensional oxides as new catalytic materials</td>
<td></td>
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<tr>
<td>December 6, 2019</td>
<td>Andres Castellanos Gomez</td>
<td>2D semiconductors for optoelectronic and straintronics</td>
<td></td>
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<tr>
<td>December 20, 2019</td>
<td>Alexander Eychmüller</td>
<td>The journey of colloidal semiconductor nanocrystals</td>
<td></td>
</tr>
</tbody>
</table>
Principle Investigators at UNAM

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Principle Investigators at UNAM

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UNAM Research Group Highlights
[Advanced Materials (cover), DOI: 10.1002/adma.202070077].
Our laboratory’s research focus is aimed at understanding age-related alterations in neural cells and synapses and effects of dietary restriction (DR) in preventing these changes. We are determining the molecular pathways through which DR is exerting these effects to develop possible drug mimetics that would be translatable to human populations.

Aging is a complex process, regulated by the interplay between genetic and environmental factors with multifactorial changes affecting many systems. Normal aging is accompanied by cognitive decline and understanding the mechanisms at the cellular and synaptic levels will provide insight into the biological changes that underlie this decline. Developing strategies for ameliorating and preventing cognitive changes and potential translational therapies for the aging population are important goals. Dietary restriction (DR) is a dietary regimen that is based on lowering the daily caloric intake. DR animals have higher mean life and health spans, delayed age-related physiological changes, and better performance on memory tasks. The differential effects of DR, such as the gender of the subject, timing and duration, as well as the specific molecular mechanisms of DR are unknown. Also, development of potential DR-mimetics, drugs that mimic the effects of DR, is important. We are using the zebra fish as a model organism to study the effects of aging and DR on changes in neural cells and synapses because just like humans they age gradually and many genetic tools are available for determining the mechanisms of DR in these animals. Thus far, we have observed that neurogenesis is decreased in aged animals and synaptic protein levels show a sexually dimorphic pattern with brain aging.

We have begun to apply an every-other-day DR feeding regimen to determine the effects of these interventions on neural cells and synapses. Initial data indicates that telomere lengths but not neurogenesis rates are affected by age and DR. We are currently using a DR-mimetic, rapamycin, which blocks the nutrient signaling pathway to examine the molecular mechanisms of DR. Moreover, we are creating transgenic fish with changed nutrient signaling pathway to determine if we can obtain accelerated or decelerated aging models. Protein levels show a sexually dimorphic pattern with brain aging. We have begun to apply CR and CR-mimetics to determine the molecular pathways of these interventions.

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Research interests: Cellular and synaptic changes in the aging brains

---

**Alterations in Neural Cells and Synapses with Aging and Diet**

![Image of research data](image_url)
Transmission electron microscopic section through the Zebra fish brain.
Arrow: Cross section of microtubules;
Asterisk: mitochondria;
Hyphen: vesicles;
Double asterisks: synapse
(Arslan-Ergul et al.,)
Mechanochemistry

In our research group, we develop new materials and methods to efficiently convert mechanical energy to chemical energy.

Mechanochemistry is the conversion of mechanical energy exerted on materials (i.e. tension, compression, or even a simple contact of two surfaces) to chemical energy via chemical bond breakages. The increasing demand for finding new energy sources and ever-increasing value of feedstock materials recently boosted the interest in mechanochemical research for finding new pathways for energy conversions and development of new technologies e.g. in the field of recycling. Our research group aims to find such systems to perform efficient mechanical-to-chemical energy conversions.

Polymer mechanochemistry

Growth in the production of polymeric materials (reaching 245 million tons per annum as of 2009, with estimated worldwide sales of $454 billion, which are expected to reach $567 billion by 2017, with an average growth rate of 3.8% between 2012 and 2017) and the expansion of their uses make polymers a primary class of materials. Polymer mechanochemistry has recently gained more importance with the growth in production of polymer materials as well as with the growing interest in retrieving energy from organic/polymer materials. In our group, we both work on mechanochemistry of the common polymers produced and used in large quantities everyday, and also produce new materials and methods that will finally be reflected in innovative technologies i.e. in energy conversion and recycling.

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Mechanochemistry, polymers for energy applications, soft robots

Macroscopic level
• crazing
Nanoscopic level
• chain elongation
• chain slipping
Molecular level
• bond breaking
The universe is computational at its essence. It is woven with mathematical consistency out of information fabric. Computers are used to probe the universe at all scales, from atoms to galaxies. Our group explores the computational universe in search of novel materials and intelligent life.

**Computational Universe**

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MSN Graduate Program and UNAM Interdisciplinary Neuroscience Program  
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**Research interests:** Computational condensed matter physics, complex systems, computational neuroscience
Discovering Novel Materials

A century after quantum mechanics was conceived, we are now able to predict the stability and physical properties of materials that don’t even exist in Nature. Our predictions have enough precision to guide or understand experimental studies. This precision is reached by implementing the Density Functional Theory in efficient algorithms that run in supercomputers.

Artificial Life

The universe is painstakingly explored by ever stronger telescopes in search of places that can inhabit life. Since the dawn of the information age we have started looking for life-like behavior in our computers. Such an exploration in the computational universe involves building models that aspire to biological neurocircuitry. In this respect, our group is after a simple computational model of brain that can acquire intelligent behavior through evolution.
Our research focuses on the design, simulation, fabrication, and testing of novel nanophotonic devices targeting diverse applications.

The future “digital economy” and “green” technologies need more energy efficient devices than today. Optoelectronics and photonics have contributed extensively in these areas and can help reduce the energy budget and increase the capabilities of these technologies with innovative photonic components and light sources. To this end, we work on the development of novel nanophotonic devices and semiconductor laser technologies. Today, they are employed in a wide range of applications in information communication technologies, medical diagnostics, industrial cutting/heating systems, infrared illumination for surveillance, 3D sensors, light detection and ranging (LIDAR), homeland security and military, environmental monitoring and self-driving cars. Advances in these devices require the development of disruptive technologies that involve industry-oriented mindset with a scientific research approach, a deep understanding of the current technology and its limits.
In the nanoPhD Lab, we work on novel device architectures with unprecedented features and abilities. We design the epitaxial structure of photonic devices with nanoscale precision. We also use simulation tools to study and understand their thermo-opto-electronic behavior. The designed nanophotonic devices are manufactured in our clean rooms using micro- & nano-fabrication processes developed by the group and finally tested in our laboratory.

Our projects embrace both applied science and industry-oriented research. Our expertise includes a wide range of nanophotonic devices: semiconductor lasers, high-power laser diodes, vertical cavity surface emitting lasers (VCSEL), low-dimensional quantum well/dot structures, nanolasers, parity-time symmetry in lasers and quantum cascade laser (QCL).

One of our fundamental research goal is to extend our industrial research results on laser power enhancement. Within the last decade, it remained challenging to increase the output power of semiconductor lasers. Various explanations were proposed to limit laser power, but the physical mechanisms have remained unclear. Our work showed that both linear and non-linear losses contribute to laser power limitation. As a solution, we proposed semiconductor laser power increase by control of gain and power profiles. By employing this method, we demonstrated world record laser power. We also work on approaches that can potentially lead to diffraction limited high-power laser chips. For this purpose, we conduct simulation and experimental studies on parity-time symmetry in semiconductor lasers.

We also develop novel architectures to solve the longstanding problems of laser diodes. Catastrophic optical mirror damage (COMD) has been known as a fundamental issue limiting both device reliability and performance of semiconductor lasers. It is a heating induced failure of the output facet and, hence, the laser diode. Recently, we demonstrated a method to isolate the generated heat of the laser from its temperature sensitive output facet. We showed facet cooling of a semiconductor laser with facet temperatures far below the bulk temperature of the laser cavity without compromising the laser performance.

Progress in laser miniaturization started with the invention of VCSELs. However, it has been impossible to achieve manufacturable nanolasers using the existing technology. Other small size laser approaches have been demonstrated in the past few decades such as micro-disks, photonic crystals, nanowire, and plasmonic lasers with limited success. We have recently started working on a method to develop a novel growth and fabrication process for manufacturable nanolasers.
The Demir Research Group is working on high-tech material platforms and innovative devices embedded with nanoscale functional structures. Under the leadership of Professor Hilmi Volkan Demir, the research group focuses on studying semiconductor optoelectronics of nanocrystals including colloidal quantum dots and atomically-flat quantum wells, physics of colloidal nanophotonics (excitonics, plasmonics), and nanoparticle photonics. Also, the team develops energy-transfer driven quantum devices/sensors and light-emitting diodes for quality lighting, and bioimplants, implantable electronics and medical devices.

The Demir Group has published more than 340 peer-reviewed research articles in major scientific journals. In 2019, out of 26 publications, 15 of them are Nature Index Journals and/or have IF~10 and above. Another important event of 2019 was the election of the group leader Professor Demir as a Fellow of The Optical Society (OSA). Prof. Demir’s promotion to Fellow status recognizes his distinct and significant contributions to the advancement of optics and photonics, in particular for pioneering and sustained contributions to the research and development of semiconductor nanocrystal optoelectronics semiconductor lighting and nanophotonics.
Studies in the last few years have enabled colloidal quantum wells (CQWs), with superior optical properties such as spectrally narrow photoluminescence, strong light absorption and polarized light emission to join the semiconductor nanocrystal family as wonder-nanoparticles. Although CQWs have these superior optical properties, the performance of CQW-LEDs had fallen behind colloidal-quantum-dot LEDs (CQD-LEDs) and other types of LEDs. This year, we reported CQW-LEDs with a record high external quantum efficiency (EQE) on par with other LED types, such as OLEDs, CQD-LEDs, and PeLEDs. To obtain the high electroluminescence (EL) performance, core/hot-injection shell (HIS) grown CQWs have been utilized, which is key to achieve near-unity photoluminescence quantum yield (PLQY), reduced nonradiative emission, smooth film, and improved stability. Importantly, even after five times of cleaning, the PLQY still remains as high as 95% in solution and 87% in solid state film, which is highly desirable to utilize them in LEDs. We proposed that the shape of CQWs plays a crucial role in the performance of LEDs. The square CQW-based LEDs show higher efficiency than rod-like and rectangular CQW-based LEDs. We present that the optimized composition of core/HIS CQWs is significant to enhance the device efficiency by reducing the lattice mismatch between core and shell materials. As a result, we showed that the optimized CQW-LEDs obtained in this study have an EQE of 19%, the highest EQE reported for CQW-LEDs to date.

[Advanced Materials, (cover), DOI: 10.1002/adma.201905824. (Nature Index Journal)].

Another interesting study conducted by the Demir Research Group in 2019 is the synthesis of ultra-thin, two-dimensional nanostructures with a high performance level of luminescence. These two-monolayer colloidal CdSe nanoplatelet structures have recently attracted a great deal of interest owing to their exceptional electronic structure and optical characteristics originating from their highly anisotropic thin structure. 2D materials have recently attracted a great deal of interest owing to their exceptional electronic structure and optical characteristics originating from their highly anisotropic thin structure. Their 2D structure offers superior conductivity in the lateral dimension compared to the other colloidal nanostructures since carriers can move freely in plane without encountering boundaries or barriers, which makes them advantageous for novel electronic and optoelectronic devices. These ultrathin NPLs having thickness of only ~0.7 nm exhibits broad photoluminescence emission covering the visible region with quantum yields reaching 90%. The intrinsic absorption of the two-monolayer (2 ML) CdSe NPLs reported in this study is almost an order of magnitude larger than that of CdSe quantum dots signifying the presence of giant oscillator strength (GOST) and hence making them favorable candidates for next-generation light-emitting and -harvesting applications. Also, hybrid LED developed by employing 2 ML CdSe NPLs as color converters exhibit very high luminous efficacy of 300 lm/W as a result of the strong overlap of the emission with the human eye sensitivity function and exceptionally high quantum yield of our NPL solids.

[Advanced Functional Materials, 2019, 29, 1901028 (Nature Index Journal)].

Field interactions with colloidal quantum wells due to orientation has been shown. A self-assembly technique has been developed to deposit a single colloidal quantum well layer in a desired single direction (face down or edge up). The resulting films were used to study the near-field nonradiative interactions between these quantum wells and another class of nanocrystals. Our team showed that the strength of this interaction is greatly influenced by the orientation of the quantum wells. To this end, our team proposed and developed a self-assembly technique, which enabled them not only to control the orientation of these quantum wells, but also to deposit them in a single layer with full surface coverage over areas as large as ~20 cm². With the help of these thin films, the phenomenon of nonradiative energy transfer from another class of nanocrystals, namely spherical quantum dots, to these oriented quantum wells was studied. Through this systematic study, it was found out that the energy transfer is significantly stronger to the vertically-oriented quantum well monolayers compared to that to flat-lying ones. In addition, a theoretical model that successfully predicts the energy transfer rate to quantum wells in both directions has been developed in this study.

[Nano Letters, 2019, 19, 4297−4305 (Nature Index Journal)].
Grubumuzda fizik, kimya ve malzeme bilimi alanlarını bir araya getiren çok disiplinli hesaplama bilimi üzerine çalışmalar yapmaktayız. Dünya çapında önem arz eden kritik problemleri çözmek için en üst seviyede modeleme ve simülasyon uygulamalarını kullanmakta, üstün özelliklere sahip yeni malzemeleri öngörme ve tasarlama çalışmalarında bulunmaktayız. Araştırmalarımız genel olarak iki-boyutlu nano-yapılar, ve yüksek termoelektrik performanslı ultra-ince sistemler üzerine yoğunlaştıktadır.

Two-dimensional (2D) Materials

Following the synthesis of single-layer graphene and demonstrations of graphene-based devices, 2D materials have become the focus of both experimental and theoretical studies. Unusual quantum effects provided by the reduction of dimension of the bulk materials to 2D form would bring very important innovations in already existing technologies. In this framework our main goal is to design and functionalize these novel systems and predict their possible applications.

Currently, we are working on the new-generation 2D materials composed of three components (ternary), as well as discovering the structurally stable phases, characterization of their fundamental properties, and unveiling superior features. These results will determine the potential uses of these materials in advanced technological applications. This new class of Janus 2D materials comprising various combinations of three different elements will pave the way for realizing numerous new materials; with symmetry breaking and superior properties compared to other 2D systems.

Thermoelectric properties of ultrathin systems

Thermoelectric effect is defined as the conversion of temperature difference directly into electrical potential, or in a similar manner; the creation of difference in temperature by the electrical potential. Materials featuring substantial thermoelectric properties can be utilized in energy transformation (heat to electrical energy) and cooling applications. A significant portion of the energy used up for various reasons all over the world is being wasted in the form of heat, causing problems such as excess energy costs and global warming. Reusing wasted heat through thermoelectric materials could serve as an efficient method for cost-effective solutions of the increasing energy requirements, global warming and environmental pollution. Moreover, thermoelectric devices can be utilized for cooling problems in small integrated circuits. Highly efficient, integrable and cost-effective materials are needed in order to exploit thermoelectric effect in practical applications. However, increasing the thermoelectric efficiency is not a trivial task. Among new approaches that may overcome the classical limits, nano-sized materials have been proposed with promising results being obtained. Stemmed from this motivation, we are investigating and synthesizing various ultrathin systems to achieve high thermoelectric efficiency.
Today, we are able to describe the behaviour of atoms and molecules in quantum world with computer simulations.
We are working on fundamental understanding and applications of fluid flow at small scale. We are specifically interested in control of liquids with extreme precision for biochemical applications. Our research is divided into three themes: Droplet fluidic systems, viscoelastic fluids and hemorheology. In droplet fluidic systems, exquisite control of picoliter volume fluid packages enables high throughput studies using minute amounts of samples. Such systems address a broad range of applications. We explore applications in particle synthesis and single cell studies. In 2019, we have demonstrated that using an impedimetric detection system we can measure the droplet physical parameters and form monodisperse polymeric particles at a desired monodispersity (Lab Chip, 19, 3815-24, 2019). This real-time measurement capability allows on-demand particle synthesis with a pre-set size distribution (impedimetric-droplet.weebly.com). Additionally, we are working on droplet generation dynamics to achieve monodispersity that is close to the theoretical limit dictated by multi-phase flow mechanics. The improvement of droplet monodispersity reflects itself as an improvement in precision of all the assays performed using drop fluidic systems. Our latest results reveal that we can obtain world-record monodispersity values (CV < 0.2%) using pressure-driven droplet fluidic generators.
Another research line in our group is rheological properties of blood and development of novel point-of-care diagnostic devices. Hemorheology investigates blood flow characteristics determined mainly by red blood cell (RBC) deformation, RBC aggregation, and blood viscoelasticity. These properties are intricately interdependent and a complete hemorheological analysis necessitates multiple benchtop devices, some of which are not available even in high-end medical centers. Consequently, hemorheological measurements are rarely, if not at all, conveyed in clinics. We are working on the development of a novel optofluidic method for simultaneous analysis of hemorheological properties from 50 μl undiluted blood in a few minutes. The assay differentiates hemorheological differences of blood by optically investigating collective RBC movements using a handheld analyzer and disposable cartridges.

We have also devised a prototype for rapid detection of newborn jaundice using optical total serum bilirubin detection from 10 μl of heel-prick blood. Jaundice is a critical condition especially for premature births, although it is also commonly seen in term births. Preemies have less than 200 ml of whole blood which needs to be sampled for monitoring their health conditions. Therefore, every single drop of preemies blood is invaluable. In the current practice, monitoring of jaundice level is performed either by costly and time-consuming laboratory analysis, which requires high sample volume or using transcutaneous measurements sacrificing precision. We have developed a handheld system which integrates on-chip plasma separation and provides laboratory quality results in 2 minutes. The system works very similar to point-of-care glucometers; it is composed of a user friendly analyzer with single use cartridges. The system is licensed to Ertunc Ozcan A.S and currently clinical tests are being performed at neonatal units.

We are working on the intricate flow properties of viscoelastic fluids, which are very commonly used in our life. We are interested in the rheological properties of viscoelastic fluids and the behaviour of micro/nanoparticles suspended in such fluids. The interaction of the fluid with the shear gradient in the channel leads to intriguing particle migration behaviour. In 2019, we have shown that viscoelastic fluids can be used for focusing of microbeads and blood cells inside microfluidic channels, which is crucial for optical or impedimetric flow cytometry systems. More interestingly, we have shown that non-spherical cells, such as red blood cells, can be focused at the center of the microchannels in a single orientation using viscoelastic lift forces. This allows detection of red blood cells anomalies based on deformation and size variation using cytometry systems (Electrophoresis, 40, 906-13, 2019).

We have also demonstrated the coupling between electrophoretic forces and viscoelastic lift forces that we coined as electro-viscoelastic migration (EVM). We are working on a unifying EVM theory explaining the particle migration behaviour in simultaneously applied pressure driven flow and electric field. This theory explains the particle migration behaviour in most Newtonian and viscoelastic solutions. Using EVM, cells, polyelectrolytes, DNA, biopolymers, and proteins in complex medium such as whole blood or biological sera can be precisely focused and separated according to their charge and polymeric as in electrophoresis or chromatography applications.
“Protein-DNA interactions determine the 3D structure of double stranded DNA in cell nucleus or bacterial volume.”

What is common between the DNA carrying your genetic information from generations to generations and the plastic bottles you sip your water from? These “soft-matter” systems are composed of often relatively long molecular structures with diverse chemical structures that we call polymer. Polymers, whether as the constituents of a biological or a human-made system, can respond to external stimuli on the order of thermal fluctuations, such as mechanical stress, electric field, flow, pH level, or temperature/concentration gradients, etc. They can also transiently adapt geometrical constraints. While all this versatility of polymeric soft-matter, on one hand, provides unprecedented survival and evolutionary capabilities for life (e.g., compaction of meters-long DNA in your cells), on the other hand, create new opportunities to design next-generation materials and pharmaceutical solutions.

Research in our lab focuses on fundamental problems in biology and materials sciences, on which we have currently either none or limited understanding. Specifically, we study the kinetic and stimuli-responsive properties of synthetic and biological polymeric systems. Some examples are polyelectrolyte hydrogels’ mechanical and electric response or kinetics of protein-DNA interactions, and their role in chromatin organization, just to name a few. In our investigations, we use Molecular Dynamics (MD) simulations both on atomistic and coarse-grained levels, along with analytical tools of statistical mechanics.

Research interests: Statistical mechanical and thermodynamic description of soft matter, biophysics, polymer physics

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Protein–DNA interactions and their role in the 3D structure of genome

In all mammalian cells of (e.g., human cells), the meters-long DNA molecule can squeeze into a micro-meter scale cell nucleus. Typically, a more compact form of the DNA (i.e., heterochromatin) resides near the interfaces of the cell nucleus, whereas, in other nuclear locations, a less compact form of the DNA (i.e., euchromatin) is observed. The DNA can form these structures via its interactions with a vast array of heterogeneously distributed nucleic acid binding proteins and ions (monovalent or multivalent salts such as Na+, Mg2+). Strikingly, any irregularity in DNA compaction states can be traced back to DNA-protein interactions, which are also hallmark of many malignant disorders, including cancer and progeria (i.e., early aging) syndrome. In our research, by considering the polymer nature of the negatively charged DNA molecule, we would like to quantitatively model the “phase” segregation of DNA by borrowing arguments from physics of polymers and self-assembly. Our ultimate goal is to decipher the fundamental mechanism of DNA organization in confinement, thus, resolve unknowns of mechanochemical aspects of diseases mechanisms.

Stimuli-responsive polymers
Biofriction; Biological systems are good at handing friction under extreme conditions; For instance, every time a human jumps and lands on her feet, synovial tissues in knees endure pressures on the orders of mega pascals while minimizing frictional forces between moving joints. Similarly, eyelids open and close with velocities on the orders of meters per second (10 m/s = 36 km/h), nevertheless, natural lubricants coating retina hinder damage and wear in healthy eyes. In these and other connective tissues undergoing relative motion, the frictional forces are reduced by glycoprotein-rich charged polymers carpeting the relatively moving mesoscopic surfaces (e.g., synovial joints, mucin layers between cornea and eyelids). These biopolymer structures (what we refer to as polyelectrolytes) optimize the dissipation and adhesion under extreme mechanical conditions, such as high pressure and velocities. However, exact friction mechanism and functionality of the biopolymer layers in these systems have not been fully revealed yet. The research in our lab investigates shear and normal-forces acting on these polymer-grafted structures. This research, on one hand, will help us understand how nature deals with frictional forces at nanoscales, on the other hand, will open new doors to propose design principles for biomimetic materials and scalable microscale devices.

Conduction and filtration in polymer membranes
In desalination system, in which seawater is processed to obtain drinking water, or in other filtration problems such as dialysis, separation, and selection of the ionic components in a precise manner is the ultimate challenge while ensuring the reusability of filtration components. In addition, future battery applications require light-weight and cheap electrolyte materials that can allow high energy densities. Charged polymer systems can, indeed, offer solutions for both filtration and energy applications; While charged polymers can conduct ions through their heterogeneous structures, with well-defined and tailored designs, they can be used as selective membranes for filtrations applications. However, to utilize polymers in these applications, molecular-scale behavior of charged polymers to external flows and electric fields should be understood in detail. Our research aims to correlate the microscopic structure with macroscopic properties, which are of paramount interest for the engineering applications mentioned above. We would like to answer questions such as how ionic distribution increases charge-transfer efficiency in hydrogels, or how frequency-dependent external fields alter ionic correlations and propagation in polymeric media. Findings of our research will help development of modern filtration and conduction systems for energy, environmental as well as medical applications.
My laboratory’s research focus is at the intersection of nutrient-sensitive, inflammatory and stress pathways in the context of chronic inflammatory and metabolic diseases such as obesity, diabetes and atherosclerosis. Our goal is to identify novel therapeutic targets and biomarkers for this disease cluster. Our multidisciplinary approach includes molecular biology, chemical-genetics, RNA-sequencing, proteomics, metabolomics, transgenic mice, advanced imaging and nanobiotechnology methods.

How do the excess of nutrients engage inflammatory and stress pathways in cells and lead to the development of chronic metabolic and inflammatory diseases? One clue is the chronic overloading of anabolic and catabolic organelles by nutrients leads to metabolic stress. Indeed, metabolic overload leads to endoplasmic reticulum (ER) stress and activates the unfolded protein response (UPR). We are interested in ER’s unconventional mechanisms of sensing lipids and its role in coupling nutrients to inflammatory responses. Our major goal is to probe the molecular differences between the detrimental consequences of metabolic ER stress and the adaptive UPR signaling that could be therapeutically exploited in chronic metabolic diseases. The UPR consists of three branches, however, specific tools to control any of these arms are not available.

Our approach to this problem involves using chemical-genetics to specifically modulate the activities of proximal kinases in the ER stress response. This method allows mono-specific activation or inhibition of only the modified kinase in cells and tissues in vivo. This will be coupled with substrate discovery and creation of transgenic mouse models.

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**Novel Therapeutics and Diagnostics for Cardiometabolic Syndrome**

My laboratory’s research focus is at the intersection of nutrient-sensitive, inflammatory and stress pathways in the context of chronic inflammatory and metabolic diseases such as obesity, diabetes and atherosclerosis. Our goal is to identify novel therapeutic targets and biomarkers for this disease cluster. Our multidisciplinary approach includes molecular biology, chemical-genetics, RNA-sequencing, proteomics, metabolomics, transgenic mice, advanced imaging and nanobiotechnology methods.
Micro and Nano Integrated Fluidics (MiNI) focuses on using microfluidics as a tool for nanotechnology applications. The main focus is nanomaterial synthesis, manipulation and printing via microfluidics. Current techniques for nanomaterial synthesis lacks the ability to control reaction conditions, resulting in polydispersity. Microfluidics not only provides a controlled environment for synthesis but also the ability to perform post-processing such as shell coating or functionalization.

MiNI Lab is a research group that brings microfluidic solutions to nanomaterial technology. Nanomaterials such as nanoparticles, nanorods or nanowires, have unique properties that highly depend on their size; therefore it is crucial to be able to perform synthesis reactions with superior control over reaction conditions to achieve monodispersity. Monodisperse particles can be later functionalized and printed on surfaces to form sensors, or other smart surfaces. In MiNI Lab there are two approaches for microfluidic systems for the synthesis and manipulation of nanomaterials. The first one is microchannel based approach, where solvents are passed through channels and synthesis is based on the mixing and heating of these solvents inside the channels. The second approach is the surface approach, where droplets are moved on a textured surface without being enclosed in a channel. By creating local energy gradients on the surface, droplets of liquid can be manipulated by supplying an external energy such as vertical vibration of the surface. With the second approach, nanomaterial synthesis can be realized in small droplets and later these droplets can be carried to specific locations for immobilization and printing.

In the MiNI Lab we plan to develop microfluidic networks for assembling nanomaterials on substrates to create smart surfaces. Nanomaterials can be delivered to specific locations by using a combination of microfluidic channels and textured surfaces. Once they are delivered to the location, the solvent can be evaporated selectively. By using this network, different nanoparticles can be assembled on the same substrate at precise locations. This method is a mechanical way of assembling nanoparticles therefore it is independent of substrate material and does not require chemical modification of the surface. These smart surfaces have two application areas. The first application area is biosensing. Functionalized nanoparticles with biomolecules are used for biosensing applications to enable point-of-care diagnostics. The second promising application area of these smart surfaces is energy harvesting from random mechanical motions.
Within solid tumors cancer cells have pivotal roles in orchestrating immune reactions to create an inflammatory microenvironment that favors tumor development.

Our previous work (Greten et al. 2007, Cell; Schwitalla et al. 2013, Cell; Stellzig et al. 2013, Oncogenesis; Göktuna et al. 2014, Cell Reports; Chau and Göktuna et al. 2015, Journal of Immunology; Ladang et al. 2015, Journal of Experimental Medicine; Göktuna et al. 2016 Cancer Research) had focused on identifying key signaling pathways that regulate cytokine and chemokine signaling to direct inflammatory cell activations in mouse models of colorectal tumorigenesis. Eventually, we identified key mechanisms that regulate interactions of epithelial and immune cells which may enable us to develop therapeutic tools to interfere with tumor development regardless of stage and resistance to chemotherapeutics. Hence, we will utilize diverse mouse models of tumorigenesis together with transgenic mouse models to identify how diverse cytokine signaling pathways are regulated within different cell types in the tumor microenvironment and how these regulations affect tumor development in different cancers.

We also want to expand our knowledge on the regulation of tumor microenvironment by the microbiota to develop better understanding of their roles in disease and health.

Besides, we want to develop mouse models of inflammatory bowel diseases to understand risk factors and how these diseases are connected to colorectal cancer development in different settings.

Our expertise comprises handling of in vivo samples for various disease models, generation of primary cell lines, isolation of immune cells and their characterization via flow cytometry, adoptive transplants of immune cells into host animals, various histological procedures for identifying specific phenotypes, handling colorectal cancer cell lines for various cellular assays and lentivirus based loss-of-function experiments, and almost all molecular biology techniques that will be required for basic research scientists (cloning, transfections, high or low throughput gene expression profiling, protein expression, interaction and modification studies etc.). We are also aiming to adopt recent technologies like CRISPR/Cas9 gene editing in cell cultures and in vitro organoid cultures with our future studies.
We work on sensing and advanced dynamics problems using two distinct family of cutting-edge technologies: Nano-electromechanical Systems (NEMS) and Microfluidic-Integrated Microwave Sensors (MIMS). With NEMS technology, we have developed nonlinear sensors capable of sizing single nanoparticles in real time under vacuum. Also, using novel NEMS devices based on buckling, we are investigating the intricate connection between thermodynamics and information processing. With the MIMS technology, on the other hand, we are developing single-cell sensors for life science applications.

NEMS
Nano-electromechanical Systems (NEMS) are electronically controllable, submicron-scale mechanical devices used in fundamental studies as well as application-oriented efforts. The field has been under active development since the early-1990s. NEMS technology has recently begun to transform from the domain of academic laboratories into the domain of microelectronic foundries, especially within the framework of Nanosystems Alliance. It is now possible to create thousands of devices in a single process run and use these devices in sensor experiments.

Dr. Hanay has led some of the seminal experiments with NEMS sensors, for instance the detection and mass spectrometry of single protein molecules during his PhD studies at Caltech. By establishing a state-of-the-art NEMS laboratory at Bilkent University, further research projects in sensing and dynamics are being pursued. For instance, the nonlinear regime of nanomechanical sensors are usually avoided in applications: however, Dr. Hanay’s group has developed a novel Trajectory-Locked Loop (TLL) to monitor a nonlinear nanomechanical sensor. With this system, gold nanoparticles have been detected and characterized one by one. This work has been published in Nano Letters in 2019.

Another major strand with NEMS devices concerns the dynamics of information engines. The fundamental question here is the energetic cost of computation processes. The lack of precisely controllable nanoscale systems had been hindering the progress on this front. With a novel buckling based nanomechanical system, Dr. Hanay’s research group demonstrated basic digital storage operations and controlled the hysteresis of device switching, a critical step for uncovering the thermodynamics of information processing. The buckling platform can also be operated as a nanoscale robotic system. This work will appear in Physical Review Letters in January 2020 and be highlighted as Editor’s Choice.

MIMS
For systematic diseases like cancer, it is critical to develop personalized medicine approaches. For instance, the ability to measure the effect of each specific drug on the tumor cells of a patient is of paramount importance. We are developing novel microwave sensors integrated with a microfluidics delivery system to analyze single cells quantitatively and with high throughput. Our efforts in this field are supported by an ERC Starting Grant.
“Thanks to their small dimensions and high resonance frequencies, NEMS are excellent sensors of physical changes. Low-noise electronic measurement techniques are at the heart of progress in NEMS based sensors.”
Ultrafast Fiber Lasers and Nonlinear Feedback-driven Laser-Material Interactions

The Ultrafast Optics and Lasers Laboratory (UFOLAB, http://ufolab.bilkent.edu.tr), led by Dr. Ilday, focuses on the physics of mode-locking [1] that enables the generation of ultrashort pulses from lasers, as well as pioneering the concept of nonlinear feedback-driven laser-material interactions [2-5]. Dr. Ilday was the first to propose to apply the basic concept of mode-locking to self-organized pattern and structure formation [2,3]. The commonality between mode-locking and this approach is to harness feedback mechanisms that arise intrinsically: When a laser beam modifies the properties of a material, this, in turn, changes how the next laser pulse interacts with the same material. Such two-way interactions lead to a feedback mechanism, whereby, akin to mode-locking, one only has to arrange for any desired pattern to have higher feedback gain for it to emerge spontaneously and effortlessly. This concept was later generalized to other applications, such as 3D hologram generation [4] and ultra-efficient ablation [5], achieving striking results that were previously thought to be impossible.

Ablation-cooled laser-material removal
UFOLAB has recently invented a new regime of laser-material processing [5], which is accessed with ultrafast pulse repetition rates in the range of multi-GHz, in contrast to the traditional ultrafast regime using kHz repetition rates. As a result, UFOLAB has achieved 10-100 times higher ablation efficiency (volume per incident energy). At the GHz repetition rates, there is so little time between the pulses that heat diffusion becomes negligible compared to cooling by the ejection of material during ablation, hence the name, ablation cooled. This is the fundamental reason for increased efficiency. Also, instead of using 10s to 100s of microjoule pulse energy, several orders of magnitude lower energies are used. This is so because, in the ablation-cooled regime, thousands of pulses interact collectively with the material.

A new class of ultra-efficient high-power fiber lasers
Ablation-cooled material processing motivates a radically different laser technology, for which fiber lasers are ideal: Instead of high energies, the target becomes high repetition rates, and as short pulses as possible. UFOLAB is now pioneering the development of a novel class of ultrafast fiber lasers with an entirely different architecture and far higher wallplug efficiencies than existing ultrafast lasers.

Precision material processing with record-high speed and efficiency
The benefits of the ablation-cooled regime has been proven on a diverse and rapidly expanding set of industrially important materials, including various metals, semiconductors, heat-sensitive piezoelectric and magnetic materials, different medical implants, glasses and other transparent materials.

Ultrafast and ultra-efficient laser surgery
The most important future application of this regime will likely be laser surgery. UFOLAB has already reported record-high speeds in the cutting of brain, corneal tissue, and dentine [5]. UFOLAB is working with medical doctors to develop ultrafast and ultra-efficient laser surgeries.

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Research interests: Fiber lasers, nonlinear and ultrafast optics, biomedical applications of lasers, nonlinear and stochastic dynamics, micro- and nano-structuring of matter via laser light, and nanophotonics.
“Inspired by Nature, where spontaneous emergence of structure and functionality is ubiquitous, we aim to develop a different kind of engineering, nonlinearity engineering, based on exploitation of complex nonlinear dynamics through judicious use of intense laser beams.”
Micro/Nano-Scale Platforms For Precision Health Approaches

The future of biology and medicine lies at the intersection of materials science, nanotechnology, engineering, and chemistry. In particular, the fields of micro- and nano-scale technologies and biomedical engineering have seen an unprecedented growth and development over the last decade. Integration of innovative technologies at such small scales, termed as “disruptive innovation”, offers tremendous opportunities to address unmet needs and key challenges in medicine.

In this regard, our laboratory (Incilab) focuses on the design and development of micro- and nano-platforms to understand and investigate the fundamentals of health and disease status. Our research interest can be classified in three major areas:

**Precision Health Approaches:**

Health care industry is experiencing a dramatic paradigm shift from centralized-based to point-of-care (POC). Incorporating a growing number of enabling technologies with health care systems holds unique impact on delivering routine monitoring and smart health care platforms to the POC while at the same time reducing the need for skilled personnel and the cost-of-care.

In our laboratory, we harmonize microfluidics and biosensing strategies to develop disease diagnostic tools and screening tests at these settings, where individuals can easily self-monitor their health status for “precision health” applications. Ultimately, we develop mobile health approaches on a daily-basis to report disease status of individuals to physicians and caregivers, accelerating monitoring of individuals and minimizing health disparities even at the remote settings.

**Bio-Imprinted Wearable Sensors:**

Wearable devices are currently utilizing to screen personal analytical information, physical status, physiological parameters, as well as informing schedule for medication. In particular, precision health seeks to make health care contact more accessible by integrating monitoring and diagnostics into everyday life. On the other hand, biomarker information is a key point for diagnosis, monitoring disease progression, predicting disease recurrence and treatment efficacy. However, current biomarker detection strategies (antibody or nucleic acid-based systems) have impediments in keeping their stable structure while stuck to the body.

For that reason, we develop a “Wearable Patch” by combining molecular imprinting strategies and bio-compatible material production on the same platform. Imprinting target biomolecules and transferring their molecular structure into 3-D matrices do not only present high specificity in detection and also provide high stability in sensor performance. Integrating a biosensing unit to this platform, we analyze biotargets in situ, improving the quality of life and also providing continuous medical data for actively tracking diagnosis and treatment.

**Interfacing engineering toolbox with biology:**

Understanding cellular interactions requires the construction of bio-mimetic environment through conventional tissue engineering tools. Such systems, however, have some obstacles to combine physical and biological parameters at the same condition. In particular, cellular membrane proteins have key roles as they are unique sections of biological membranes, interfacing with extracellular matrix and intracellular space, as well as representing health and disease status through molecular communication mechanisms. Since they are highly produced in cells, they are major drug targets in the pharmaceutical industry. Studying with membrane proteins is challenging as they majorly contain hydrophilic and hydrophobic domains, leading to significant 3-D structural alterations in aqueous solutions.

In this regard, we aim to develop on-chip lipid bilayer systems, where many physical factors (i.e., flow and shear stress) and bio-chemical structures and agents are integrated and controlled. Such bio-mimicking integration strategies with microfluidics opens unprecedented avenues that help study the effects of dynamic forces on molecular alterations, and enable to focus on the combination of biological spatial and architectural information on cell structure/environment with the knowledge of transformation-specific alterations.
“We develop cutting-edge technologies to present precise solutions for real-world problems in biology and medicine, thereby improving human health.”
Coordination Compounds for Hydrogen Economy

Hydrogen economy is one of the most promising candidates of alternative energy sources, which is of great importance due to limited sources of fossil based fuels and the increase in global energy demand. Two of the main challenges in hydrogen economy is water-oxidation and hydrogen storage.

Solid Adsorbents for H2 Storage
Solid adsorbents that could physically adsorb hydrogen are one of the most promising class of materials since they are robust at extreme conditions and their regeneration energy is negligible. Preparation and investigation of solid adsorbents that exhibit high performance at ambient conditions is the primary objective of our research group.

Coordination Compounds for Water-oxidation Catalysis – Artificial Photosynthesis
Water-oxidation catalysis is the most critical step in water-splitting since it is a four-electron process and requires a higher potential than hydrogen evolution step.

\[ 2\text{H}_2\text{O} \rightarrow \text{O}_2 + 4\text{H}^+ + 4e^- \quad E = 0.82 \text{ V, at pH 7} \]

The preparation of convenient and efficient catalysts that will function in the ‘artificial photosynthesis’ area is one of the objectives of our group.

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Research interests: Hydrogen storage, Water oxidation catalysis

Metal Gyanide Coordination Compounds
Red and purple spheres represent the vacancies inside the network.
“We are interested mainly in the synthesis and characterization of novel inorganic and organometallic coordination polymers and multinuclear molecular complexes.”
Unlike the standard materials used in the semiconductor industry, degrees of freedom that exist in the strongly correlated electronic materials could significantly impact electronics and optoelectronics technologies. Our research interests lie in the understanding of the phenomena arising from strong electronic correlations at nano-scales and synthesis of novel materials with unusual properties.

Strongly Correlated Materials
Seeing the synthesis of an atomically thin layer

We built a chemical vapor deposition chamber that allows the real time observation of the synthesis of crystalline materials on various substrates. This eliminates the guessing of the parameters and enables a real time control of the growth condition. We synthesized many novel materials so far.

A series of pictures shows the formation of WSe$_2$ monolayer forming on a MoSe$_2$ monolayer. Scale bar is 10 µm. Pictures taken at 700 °C (Rasouli et al. Nanoscale (2019), Rasouli et al. Phys. Rev. B (Rapid Comm.) (2019))

2D Materials

Peculiar properties of graphene have attracted waves of attention and this interest has spread to the search of other layered materials. In our group we synthesize and study peculiar 2D layered materials. Our latest finding has been the synthesis of V2O$_3$ that shows metal-insulator transition at liquid nitrogen temperatures. Further, the material exhibits very interesting electronics. Moreover, we work on techniques to investigate the thermal properties of atomically thin materials.

Our group showed that vanadium dioxide shows metal insulator transition even down to 4 nm thickness in its free-standing form. Fadlelmula et al. Nano Letters (2017)

Layer by layer synthesis of V$_2$O$_3$ crystals on Al$_2$O$_3$ is enabled by the real time observation chamber. Image is captured using transmission electron microscope. Each individual bright spot is an atom. Scale bar is 2 nm.
Nature demonstrates an immense variety of dynamic adaptive self-assembled patterns particularly as part of living organisms. Operating in 'noisy' environments far from equilibrium, these patterns can self-regulate, self-heal, self-replicate, co-exist, compete, adapt, morph, and evolve. But how? How do complex phenomena emerge when large numbers of constituents interact dynamically? What happens differently far from equilibrium, and why? Understanding and steering emergent phenomena far from equilibrium is a grand challenge of condensed matter, statistical and nonlinear physics.

In 2017, we addressed a fundamental, yet open question: What are the minimum requirements for emergence of life-like behavior from nonliving systems? We reported the first dynamic adaptive colloidal crystals exhibited a rich set of adaptive behaviors analogous to those commonly associated with living organism.

In 2019, we addressed another fundamental open question: Can self-assembly methodologies transcend the specificity of the materials and systems? We showed that our method is “universal” by showing same aggregation dynamics for 3 nm quantum dots, three different microorganisms, and 15 µm large human cells.
In late 2019, Dr. Ilday was awarded the prestigious European Research Council’s prestigious Starting Grant (ERC StG) to address a profoundly fundamental question: When a dynamic adaptive system is faced with multiple choices, which one will it choose? and why? The project is ongoing. First exciting results towards the grand goal will be announced soon.

Simply Complex Lab is also working towards addressing the following questions as part of ongoing projects:

1- How do cancer cells survive in the blood stream? Which cells (epithelial or mesenchymal) are more adaptive to the dynamic and harsh physical conditions of the circulation?
2- How and why microorganisms behave differently when their environment is far from equilibrium?
3- What is the physics of life?
4- Can hypothetical zeolites, metal–organic frameworks (MOFs), hierarchical catalysts be experimentally realized under far from equilibrium conditions?
5- What new discoveries await us in the nanoworld?

Our research focuses on self-assembly, complexity, far from equilibrium systems, nonlinear, and stochastic dynamics. Our work has been published in prestigious journals including Nano Letters, Nature Communications, Nature Photonics, and recently highlighted in the media including Phys.org, MIT Tech News, Science Daily, IEEE Spectrum, Optics & Photonics News and Nanowerk.
Research in our lab focuses on developing and testing different bioinformatics, cellular and organismal models to investigate how cellular signaling is dysregulated in cancer. One of the signal transduction pathways we have been studying is cholinergic signaling. A better understanding of the role of cholinergic signals in cancer, which remains relatively understudied, can provide novel avenues for discovering effective diagnostic and treatment modalities.

Cholinergic signaling within and between cells are driven by small molecules such as acetylcholine and nicotine. Acetylcholine levels are regulated by cellular enzymes whose differential activities can be important factors in determining cancer cell’s ability to proliferate and migrate. Nicotine, the addictive compound in tobacco, has also relevance since smoking is associated with the development of multiple cancers. Acetylcholine or nicotine binds to nicotinic acetylcholine receptors (nAChRs) that are pentameric in structure and made up of homomeric or heteromeric receptor subunits. nAChR activation modulates intracellular calcium levels and eventually alters the rates of cellular proliferation, apoptosis, and migration, which are processes frequently altered in a cancer cell leading to tumor formation and at times, metastasis. Research in our lab is currently focused on developing effective models to understand cellular and functional dynamics of cholinergic signaling in breast and liver cancer cells. RNA interference (RNAi) is a potent technology enabling delivery of double-stranded small RNA molecules into the cell thus transiently downregulating a gene’s expression. This allows for testing the effect of changes in transcript levels in the cell and discovering novel functionalities that can be beneficial in treatment of cancer.

Recently we have shown that knock-down of cholinergic receptor nicotinic alpha 5, CHRNA5, in breast cancer cells leads to reduced cell viability, and increased apoptosis and drug sensitivity using siRNA molecules against CHRNA5. This new oncogenic and drug resistance-inducing role attributed to CHRNA5 in breast cancer is currently being studied using microRNA mimics alone or in combination with siRNAs as well as in the context of other cancer types. In addition, we are interested in developing cancer models using embryos of zebrafish, an aquatic vertebrate commonly used as a human disease model. Due to transparency of embryos and availability of mutant strains, zebrafish is highly amenable for examining the genotypic and phenotypic differences of cancer cells, in vivo. Recently we have demonstrated that liver cancer cells xenografted into acetylcholinesterase mutant zebrafish embryos, which accumulate excess acetylcholine in their cells, produce larger tumors than those in the wildtype siblings. Finally, the bioinformatics field also provides important tools and resources to decipher the complexities of cancer cell signaling while helping identify the impact of RNAi treatments on the cellular state of cancer cells. We use our own as well as published transcriptomics resources in humans and zebrafish to discover novel interactions among genes and signaling pathways with importance in cancer treatment and prognostication.
Biointerfaces serve as a hub for vital chemical processes. There is a delicate balance in nature to maintain the composition and conformation of these surfaces. Tiny surface modifications cause significant changes. As a consequence, understanding the molecular machinery of physiological phenomena occurring at biologically relevant interfaces is a necessity but a formidable challenge due to not having a unified methodology for all surfaces or chemical processes. In the Okur Research Group, we aim to elucidate chemical processes occurring at different biointerfaces via designing novel experiments by using nonlinear optics, spectroscopy, and modeling to reach a molecular level detailed understanding.

**Macromolecule – Ion / Osmolyte Interactions**: Ions and small molecules differ in their ability to influence proteins in aqueous solution, known as lyotropic (Hofmeister) series. This series has been shown to influence numerous solution phenomena; including but not limited to, enzyme activities and protein crystallization, ion exchange, lightning, and bubble coalescence. In the Okur Research Group, we aim to achieve a molecular-level understanding and eventually predict the interactions between charged, neutral biologically relevant additives (e.g. ions, urea, sugars) and biomacromolecules.

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**Research Interests**: Biointerfaces, water, nano-emulsions, biomacromolecules, lipid droplet organelles, specific ion effects, nonlinear spectroscopy, second harmonic generation
In Contemporary Fiber Laboratory (CFL) we focus on developing new infrared fibers for applications in light delivery, chemical detection and nonlinear optics. Optical fibers such as hollow-core photonic crystal fibers, semiconductor-core fibers and polymer optical fibers have different optical properties in a wide spectral region. Moreover, functionalization of fibers with laser micromachining and thin film coating are effective methods to exploit their usage.

**Hollow-core photonic crystal fibers (HC-PCFs)**

The extraordinary optical transmission mechanism of HC-PCFs allow us guiding the light through a hollow-core for hundreds of meters. Structuring the cladding elements around the core is essential to maintain the light guidance with low transmission losses. Furthermore, the manipulation of the cross-section of the fibers with post-drawing methods such as micromachining with femtosecond lasers and thin film coating in the fibers can widen the application of HC-PCFs. In our laboratory, we are interested in developing new HC-PCFs that can be used for light transmission in the infrared spectral region. The microstructure of the fibers are designed with the help of computer simulations, and the fibers are drawn in the draw tower at UNAM. The optical characterization of fibers is done based on the design wavelength and criteria. Additionally, visible light transmission is also possible with our HC-PCFs.

**Semiconductor-core fibers**

Semiconductor-core glass-cladded fibers have been demonstrated for the first time in the mid-2000s and have gained strong attention due to their capability of low-loss infrared transmission and high nonlinearity. In our research, we use semiconductors such as Si, Ge and Si-Ge alloys as core materials and borosilicate and silica glasses as the cladding of our fibers. The drawing and infrared optical characterization of the fibers were carried out in our laboratory. The promising results motivate us to diversify core & cladding materials to improve the optical properties of the semiconductor-core fibers.

Our ultimate goal is to integrate the semiconductors with HC-PCFs to create “Hybrid fibers” to exploit the advantages of each fiber group and develop superior fibers in the infrared region with low transmission losses.
“In CFL, drawing a variety of optical fibers such as hollow-core photonic crystal fibers, semiconductor-core fibers and polymer optical fibers forms the backbone of our research.”
Fiber laser technology including fundamental science and various applications from medicine to industry are some of the scope of ORTAÇ GROUP. A state-of-the-art fabrication technology in house is utilized to go beyond the limits of original pulsed and CW laser sources in terms of the compactness and power levels. We focus on the Laser Science and Technology and study Pulsed-Fiber Oscillators, Fiber Amplifiers, Combining of Fiber Lasers, kW-Class Fiber Lasers, and Medical Laser Systems.

Our research portfolio covers the Fiber Technology consisting of different fiber concepts, Fiber Bragg Gratings, Fiber Combiners, Fiber Integration, Cladding Light Stripper, Polishing and End-Cap. The ongoing research activities also include investigations of laser interaction with various solid and biological materials for the formation of nanomaterials with high purity, different sizes and shapes in mass-scale.

High-power fiber lasers are important and become popular in recent years due to their remarkable characteristics. Here, we also focus on the new designs both in the fabrication process of the fibers and lasers yielding high-slope efficiency.

“We target the development of new generations of active/passive fibers and combiners to be used both in pulsed and CW laser sources delivering unprecedented performance in term of the compactness, low noise, energy and power levels as versatile tools for scientific and industrial applications.”

Fiber Laser Science and Technology

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Research interests: Fiber lasers, saturable absorbers, development of high-power fiber amplification systems
The mission on developing new generation of fiber lasers doped with high concentration of rare-earth ions makes us to study their unique properties by means of nanotechnology, materials science and engineering. We attempt to improve doping concentration and uniformity thus reaching at high powers with low background losses and prevention of devitrification. For this purpose, we use a Modified Chemical Vapor Deposition (MCVD) system which gives us an opportunity to obtain the glass-fiber preforms with high purity and mass-scale production. Then, the fiber preforms are drawn to the polymer coated glass fiber in our fiber drawing tower that can be operated by a capacity over 10 km within a working day. The fibers can be drawn in a way that they preserve its initial geometry and a good mechanical performance which are optimized using our recipes. We have been recognized by the Scientific and Technological Research Council of Turkey (TUBITAK) to be the first group in Turkey of producing an active fiber which has been successfully demonstrated to operate over 1 kW laser power with an excellent beam quality. Our state-of-the art facilities allow us to characterize the fiber preforms and the fibers which get close to the commercial counterparts. For these reasons, we use throughout characterization techniques to investigate optical, elemental, mechanical and structural properties purposed to be completed with the real-time tests in the field.

We also have interests in medical field as an emerging field where the use of laser science and technology increased. We do work on medical lasers and medical optical fibers designed for the endovenous laser ablation operations and a retinal laser system. The lasers are designed to operate either in visible or near infrared (NIR) wavelengths with a flexible range of energies which can be fabricated best to the needs of patients as requested by the medical doctors.

The intense research in Nanotechnology provide nanoparticles and nanomaterials which are promising for various applications including medical, biological, electronic, and industrial fields. This is due to advancement in the physical properties of the materials when reducing their size within nanoscale regime compared to their bulk counterparts. We are working on the generation of colloidal, pure and stable nanoparticles as well through laser ablation in various liquids and modification of them according to the intended use. The nanoparticle research continues with different collaborations and the research subjects ranges from sensor development to bio-medical applications.
The focus of research in our laboratory is characterization of mutations and mechanisms that lead to genetic disorders in humans. Our journey into the genome began nearly 25 years ago by determining the chromosomal localization of cloned genes in human and mouse to identify the molecular basis of inherited diseases. Also, we conducted classic linkage studies in large multigenerational families. Utilizing these approaches, we identified genes associated with Prader Will Syndrome, Charchot-Marie-Tooth disease type 1A, hereditary MLH1 deficiency and several different types of disequilibrium syndrome (Uner Tan syndrome, CAMRQ).

At present, we extend our studies to complex phenotypes in humans for the identification of genes associated with obesity, extreme leanness, polycystic ovarian syndrome and essential tremors. We resort to next-generation sequencing and bioinformatics approaches to explore and annotate the human genome. In collaboration with members of the neuroscience community at Bilkent as well as scientists at Rockefeller University, Yale University and University of Washington, we design further experiments to determine the expression patterns, regulation, and function of these genes. Our ultimate goal is to understand pathophysiological processes in disease states, and to devise diagnostic tests and rational treatment strategies.

In 2014, our group continued to study complex phenotypes in humans including obesity and essential tremors. Together with Dr. Tekinay from UNAM, we identified a gene which causes essential tremor and Parkinson disease. In an independent line of research, our group studies the rate of early post-zygotic mutations in humans and uncovered that de novo variation could substantially contribute to the pathogenies of human diseases.
Ozensoy research group focuses on the investigation of catalytic nanomaterials and processes for alternative energy production, energy conversion, sustainability, environment and aerospace.

Our infrastructure is geared towards synthesis of advanced catalytic material architectures, design and utilization of custom made in-situ spectroscopic methods/techniques to elucidate heterogeneous catalytic reaction mechanisms, understanding of the structure of catalytic interfaces at the molecular level and unraveling new structure-functionality relationships. Our interdisciplinary research interests overlap with a wide variety of fundamental fields ranging from physical chemistry to chemical physics, chemical engineering and material science.
We work on the development of novel catalytic nanomaterials for efficient hydrogen production from biomass side-products, photocatalytic air pollution control/water disinfection via solar energy, valorization of bio-ethanol and its catalytic conversion to added-value chemicals, automotive catalytic converter technologies, harvesting of solar energy for chemical applications and utilization of ionic liquids in aerospace propulsion technologies.

Understanding the surface chemistry of catalytic materials is challenging. Thus, Ozensoy lab addresses this challenge by using a variety of experimental and theoretical approaches. Complex catalytic systems comprised of monometallic/multi-metallic nanoparticles, mesoporous metal oxides, perovskites and zeolites are investigated with in-situ FTIR, ATR-IR, XRD, BET, Raman, TEM, EDX, EELS, SEM, ICP-MS and XPS (as well as other numerous bench-top characterization techniques available at the National Nanotechnology Research Center, UNAM). These characterization studies are also coupled to the catalytic activity/selectivity experiments which are also performed in-house using the custom-made batch reactors and flow reactors at the Ozensoy Lab.

Furthermore, catalytic reaction mechanisms are studied at the molecular level using planar single-crystal/thin film model catalysts with the help of surface sensitive ultra-high vacuum (UHV) techniques such as IRAS, TPD, LEED and XPS. These surface science experiments are also united with theoretical modeling (DFT calculations) performed by our collaborators. In addition, advanced operando measurements on the catalytic materials are performed at various international Synchrotron facilities utilizing XANES and EXAFS.
Quantum Photonics of Low-Dimensional Materials

My research group at UNAM mainly focuses on light-matter interaction in low dimensional materials such as quasi-one dimensional (1D) carbon nanotubes, two dimensional (2D) transition metal dichalcogenides (TMDs), hexagonal boron nitride (h-BN) and black phosphorous (BP). Our overarching research goal is to better understand and control light-matter interaction (by integrating emitters into different micro and nano-cavity designs) in these materials for efficient use of them in optoelectronic and quantum photonics device applications.

2D Material Based Nanophotonics:
Following the isolation of graphene in 2004, 2D material based research has gained tremendous interest among the scientific community. Although graphene has enormous mechanical, optical and electronic properties, lack of a band gap is a drawback for optoelectronics device applications where semiconductors are needed. As a complement to graphene, monolayer TMD materials with a band gaps in the visible to near infrared spectral range have been extensively studied in recent years. Due to the strong quantum confinement and reduced dielectric screening, excited electron-hole pairs (excitons) in TMDs are strongly bound. For that reason, the optical response of TMD materials is dominated by the excitonic resonances even at room temperature. The electronic band structure of TMDs makes the observation of other exciton complexes also possible in these materials. Also, the spin-orbit coupling and broken inversion symmetry in monolayer TMDs give rise to spin-valley coupling whereby valley degree of freedom can be used as an information carrier. The fundamental research related to (a) photophysics of excitons as well as other excitonic species (trions, biexcitons, dark excitons, interlayer excitons) and (b) valley physics of excitons in TMDs is carried out intensively in my research group. We are not only working with TMD materials but also working with other 2D materials (BP and hBN) as well.

Quantum Photonics with 2D Materials:
Most of the proposed applications of quantum information science require single photon sources. Delocalized valley excitons can be also trapped at defects and get localized in host TMD material. Single photon emission (non-classical light) have been observed from these localized excitons at cryogenic temperatures. Recently, color center related bright and stable single photon emission have been also observed in wide band gap hBN. In addition to high purity single photon emission, quantum light emitter must display also directional and well defined polarized indistinguishable photons combined with the high collection efficiency, which are essential building blocks of many of the quantum computing processes. In that regard, understanding and controlling the photophysics of single photon emitters both in TMDs and wide band gap hexagonal boron nitride is another research direction we pursue in our group. Our research aims to develop, design and fabricate various micro and nano-cavity structures such as 2D planar microcavity, Open-access Fabry-Perot tunable cavity and plasmonic nanocavities to obtain efficient, on-chip scalable single photon sources based on 2D materials.
The major research themes in our lab are systems-level analysis of therapy resistance and metastasis mainly in breast cancer. Importantly, how epithelial-mesenchymal transition (EMT), which is an important initiator step in metastasis, contributes to drug resistance and how we can use this knowledge to better target cancer cells is another focus in our lab. Two most aggressive subtypes of breast cancer, HER2-overexpressing and triple negative breast cancers (TNBCs) as well as ER+ breast cancer are the major disease-foci. In addition to breast cancer, we work on the molecular pathogenesis of gastrointestinal stromal tumors (GISTs).

System Biology of Cancer
We focus on how mRNA/non-coding RNA networks contribute to drug resistance which ultimately leads to metastatic disease, and how we can use this knowledge to better target cancer cells. In addition, we aim to contribute to precision medicine by identifying novel biomarkers that can aid the choice of therapeutic regimen to be used in patients with different genetic background.

Enhancing chemotherapy response in triple negative breast cancer
Triple-negative breast cancer (TNBC) is the most aggressive type of breast cancer. Chemotherapy is the mainstay therapy for TNBC patients; however, development of resistance is a major obstacle. In this line, we have developed in vivo chemo-resistant models using both xenografts and tumor transplants from an established TNBC mouse model. Combining whole genome RNA and miRNA sequencing, bioinformatics and network biology, we are identifying novel miRNAs/lncRNAs/their target networks involved in chemo-resistance, with an ultimate aim of enhancing chemo-response in TNBC. Overall, our interdisciplinary study provides preclinical data to enhance chemotherapy response in TNBC and identify biomarkers stratifying patients with higher response rate to chemotherapy.

Overcoming endocrine resistance in ER-positive breast cancer
More than 70% of breast tumors express estrogen receptor alpha (ER-alpha), which makes them ideal candidates for ER-targeting therapies. Tamoxifen has been the mainstay hormonal therapy for ER-positive breast cancer patients; however, development of resistance is a major obstacle in clinics. Considering the high incidence rate of ER-positive breast cancer with 1.2 million new cases diagnosed each year worldwide, and the significant number of cases developing drug resistance, there is an urgent need for identification of novel drug targets to overcome tamoxifen resistance. In this respect, we aim to identify novel mechanisms of tamoxifen resistance and thus pave the way for testing new combinations to improve survival in tamoxifen refractory, ER-positive breast cancer.

Novel approaches for overcoming therapeutic resistance in HER2-positive breast cancer
Trastuzumab emtansine (T-DM1, Kadcyla®) is a next generation HER2-ADC, combining trastuzumab, along with its cytostatic functions, with a potent microtubule targeting agent, DM1 (derivative of maytansine 1) via a stable linker, MCC. Based on its favorable efficacy results, T-DM1 was swiftly approved by FDA in 2013. Even though it offers a huge clinical benefit for previously treated HER2-positive breast cancer patients, a substantial number of patients eventually progress and frequently develop acquired resistance. In this context, we have implemented a combinatorial approach involving the high-throughput transcriptomics (e.g. RNA-Seq)/proteomics (e.g. RPPAs), bioinformatics/modeling tools and drug design, aiming at identifying novel targets to overcome resistance and prevent metastatic spread, by using state-of-art clinically-tested drugs or newly designed drug molecules with better efficiency.
Our research group is aiming at identifying novel targets overcoming resistance to state-of-art clinically-applied or -tested drugs and preventing metastatic spread of breast cancer. At molecular level, two major foci are proteins and non-coding RNAs, especially microRNAs in our lab.
Synthetic Biology, an emerging discipline of engineering, finds its roots in chemistry, biology, physics, electrical engineering and computer science. By integrating the principles of engineering and biology, this multidisciplinary field aims to create and redesign novel biological entities. Our group is interested in designing and implementing robust genetic circuits to build whole cell sensors. These sensors will then lead to the creation of novel biocatalysis systems, and will facilitate the production of nano/biomaterials with engineered functionality. We are also interested in discovering the potentials of synthetic gene regulatory systems and their associated elements.

Advances in synthetic biology during the last decade, have revolutionized the fields of medicine, genetic engineering and biotechnology. The ability to design new organisms with synthetic gene expression and controlled regulations for desired functionality, has paved the way towards advanced evolutionary engineering with unprecedented applications.
Synthetic circuits are formed using genes/proteins and their regulatory elements. To form a genetic circuit, well-characterized biological parts from various organisms can be utilized. Among these are nucleic acids, genetic regulatory elements and proteins. By combining these biological parts along with logic gates, memory units, biological switches (e.g. toggle switches) and biological oscillators, several biological devices can be created. In addition, a genetic language to program cellular functions can be achieved. Therefore, all the biological devices under the control of a cellular program can be engineered to perform highly complicated tasks for a specific function.

Our current research encompasses a broad spectrum of possible applications of synthetic biology ranging from diagnosis, environmental sensing and material synthesis. Through integration and combination of different sensory elements from different organisms, design and construction of novel whole cell biosensors that can generate desired output in response to specific molecules are studied. In coordination with biosensor studies, theranostics applications are sparsely explored. We are focusing on generating therapeutic output signals by making use of genetic circuitry in whole cell biosensors. In our lab we are investigating novel theranostics solutions for diseases such as diabetes, neurodegenerative disorders, viral infections and cancer. In this context, targeted therapy is the most important highlight in solutions for cancer and viral infections. Additionally, limits of functional biomaterial production and development are expanded using enhanced biological processes such as biofilm formation and biomineralization. In this sense, to achieve our goals, novel techniques and approaches of synthetic biology are optimized and perfected such as optogenetic and logic elements in our laboratory. Novel synthetic biology techniques for disease research are developed for a better understanding of the underlying mechanisms and further information can be found in detail in our recently published papers, which also rank as cover papers in their corresponding journals. SBL group is also closely collaborating with pharmaceutical companies to develop novel antibodies and protein based drug molecules.
Our research interests lie at the cross section of nanoscience, supramolecular and polymer chemistry. The main focus is on the design and synthesis of novel functional materials to be used in a variety of areas including photonics (e.g. light emitting diodes, colour converters, solid state lighting, photovoltaics, lasers and plasmonics), nanomedicine (e.g. drug delivery, vaccines, imaging, therapeutic agents) and photocatalysis. To this end, we design and synthesize materials in the form of supramolecular stimuli responsive assemblies, polymeric materials or nanomaterials depending on the application in mind.
Light emitting functional conjugated polymers and nanostructures:
We design and synthesise a number of different useful functional groups containing conjugated polymers and oligomers and exploit their applications in the areas of optoelectronics and photonics as well as nanomedicine. These oligomers and polymers can also be converted into water dispersible, stable nanostructures in the form of nanoparticles, vesicles or capsules in various sizes by tuning the reaction conditions. Depending on the structure and functional groups that oligomer and polymers carrying, these nanostructures can be pH, redox or light sensitive.

These tailor-made materials could include many interesting features and functionalities and could be designed to display unprecedented properties. For instance, they may be intrinsically fluorescent, and/or act as a photosensitizer to generate reactive oxygen species, to be used in the antibacterial and photodynamic therapies as well as they may combine more than one therapeutic agents for multi-modal therapies, e.g. chemo, photo and photothermal therapies.

Hybrid organic-inorganic nanostructures:
We combine intrinsically fluorescent conjugated oligomers/polymers with Au or Ag nanoparticles in one platform to be used as a multimodal therapeutic nanocarrier in which due to gold, photothermal therapy and the conjugated oligomer/polymer matrix photodynamic therapy would be possible. Moreover, nanoparticles could also be loaded with drug molecules for the additional chemotherapeutic effect. Imaging would also be possible due to the inherent luminescence properties of the matrix. Additionally, we are also working on the encapsulation of super paramagnetic iron oxide nanoparticle (SPIONs) by conjugated oligomers/polymers for dual optical and magnetic imaging applications.

Photoactive conjugated polyrotaxanes/Molecular switches:
Highly Luminescent CB[7]-based Conjugated Polyrotaxanes Embedded into Crystalline Matrices, Macromolecular Materials and Engineering, 2017, 302, 1700290


One Pot Synthesis of Hybrid Conjugated Oligomer-Ag Nanoparticles, ACS Omega, 2017, 5470−5477

Laser-material Interactions for Developing Micro/Nano Technologies

Light-matter interaction has fascinated humanity since very early times. Indeed, one of the earliest stories we have go back to the Roman times. Archimedes, a famous ancient scientist from Alexandria, is said to have destroyed the Roman fleet that aimed to invade his city, using “burning mirrors”. We do not know whether this story is true, but now we have advanced technologies such as lasers, that are as exciting and can be used to further push the limits.

In the Photonics Devices Laboratory, we are interested in studying fundamental light-matter interactions and applying the resulting understanding towards, (i) 3-dimensional silicon-based technologies, (ii) fundamental optical and holographic approaches, and (iii) developing novel micro/nano-fabrication technologies and optical devices.

Silicon and the third dimension

Silicon is an excellent material for microelectronics, microfluidics, microelectromechanical (MEMS) systems and integrated photonics, with untapped potential for infrared optics. Despite the broad recognition of the importance of the third dimension, current lithography methods do not allow for the fabrication of photonic devices and functional microelements directly inside silicon chips. Available 2-D devices are broadly termed “on-chip” technologies. Due to this important limitation, the bulk of the wafers are not used, and the lack of 3-D architectures and embedded optical functionalities essentially results in the waste of the bulk of wafers.

Recently, we have developed a direct-laser-writing approach to solve this important technological problem (Tokel et al., Nature Photonics, 11, 639, 2017). With this work, for the first time, we have demonstrated 3-D fabrication capability deep inside the wafer, without damaging the wafer above or below the modifications. Further, we found that, we can introduce photonic functionalities embedded inside the wafer. Thus, we have introduced the term “in-chip” in order to broadly describe these novel devices (Tokel et al., Nature Photonics, 11, 639, 2017). We are pushing the limits of fabrication resolution these elements, and aiming to realize novel in-chip nanofabrication capabilities. An important building block of this aim will be 3-D holographic projection capability.

3-D high-density holographic projection

Recently, we demonstrated a novel method for achieving truly 3D holographic projection capability (Makey et al, Nature Photonics, 13, 251, 2019). Holography is commonly seen as the most promising method for realizing true-to-life 3D images or videos. However, until recently, it has not been possible to combine complex images to realize high-density 3D holographic projections. Towards this goal, working with Dr. F. Ö. Ilday and our colleagues at Bilkent, we demonstrated such holograms. We solve this by a wavefront engineering trick, such that the projections at each depth preserve their quality, but at the same time eliminate unwanted crosstalk. We demonstrate holograms that form with full depth control without any crosstalk; producing large-volume, high-density, dynamic 3D projections with 1,000 image planes simultaneously, improving the state of the art by two orders of magnitude. We aim to use the method in developing advanced laser-writing approaches and state-of-the-art in-chip photonic technologies.

Dr. Tokel received his Ph.D. from Cornell University in Applied Physics, which is followed by his postdoctoral studies at Harvard University. He is the recipient of Young Investigator Award from the Science Academy, Turkey (BAGEP), METU Prof. Dr. Mustafa N. Parlar Foundation Research Incentive Award, TUBITAK Success Award, and Turkish Academy of Sciences Outstanding Young Investigator Award (GEBIP). His work has been published in prestigious journals including Nature Photonics, Nature Communications, ACS Nano and ACS Chemical Reviews, and commonly highlighted in national and international media, in outlets such as, MIT Tech News, Laser Focus World, Physics Today, IEEE Spectrum, Optics & Photonics News, as well as, la Repubblica, CNNTÜRK and Hüriyet newspapers.
Our research group has two research pillars where micro/nanofabrication, MEMS and UNAM’s research infrastructure are used as the development and realization tools for some of the most demanding needs for today and tomorrow, such as medical imaging, information technology, and energy.

Micro/Nanofabrication and MEMS

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Research interests:
Micro/nanofabrication, in-situ SEM nanomechanical characterization, MEMS, CMUT
**Medical imaging**

This research pillar develops and uses batch compatible (i.e. scalable) micro/nanofabrication and MEMS knowledge base for the development of novel imaging technologies such as CMUT (Capacitive Micromachined Ultrasound Transducers) devices for under the skin, and high resolution imaging via non-ionizing radiation. In this highly interdisciplinary research, we are collaborating with expert engineers and scientists from different disciplines such as physics, electrical and electronics engineering, materials science and engineering, mechanical engineering, and medical doctors specialized in radiology.

![Wafer scale production of CMUT devices. a) Micro/nanofabrication of multiple CMUT chips on 4-inch full wafers, b) Part of a CMUT chip that is imaged under an optical microscope, c) Software version of the CMUT chip masks that are designed using a layout editor.](image)

**Information technology and energy**

The second research pillar uses micro/nanofabrication and MEMS knowledge base for the development of novel MEMS devices for mechanical characterization and mechanically coupled field characterization of existing as well as novel nanomaterials at small length scales for information technology applications as well as energy applications. Having the capability to characterize, understand, and control mechanical and mechanically coupled field properties of materials at small length scales is important for various reasons. For example, characterizing the mechanical, and electromechanical properties of materials would help us have better understanding of the materials. Furthermore, understanding mechanical and electromechanical properties of materials would help us to develop materials that are designed for specific purposes. Due to these reasons, we are motivated to characterize, understand, and control the mechanical and mechanically coupled properties of the materials at small length scales. These MEMS devices that can be used for mechanical characterization and mechanically coupled field characterization can be adapted to a wide range of functional nanomaterials using a wide range of advanced in-situ characterization tools such as transmission electron microscopy (TEM), scanning electron microscopy (SEM), scanning probe microscopy (SPM), etc.

![a) In-situ SEM tensile testing MEMS device, b) Nanoscale sample that is batch-compatible integrated to the MEMS device, c) Nominal stress – nominal strain diagram of the tested polycrystalline gold sample.](image)
NATIONAL NANOTECHNOLOGY RESEARCH CENTER
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Transmission electron microscopy lies at the heart of our nanoimaging and characterization infrastructure. Electron diffraction of a specimen with apparent Kikuchi lines are shown in the image with an artistic look.


UNAM Journal Publications


76. Khandker, M. H., Arony, N. T., Haque, A. K. F., Maaza, M., Billah, M. M., and Uddin, M. A. Scattering of e(+/-) from N-2 in the energy range 1 eV-10 keV, Molecular Physics.


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