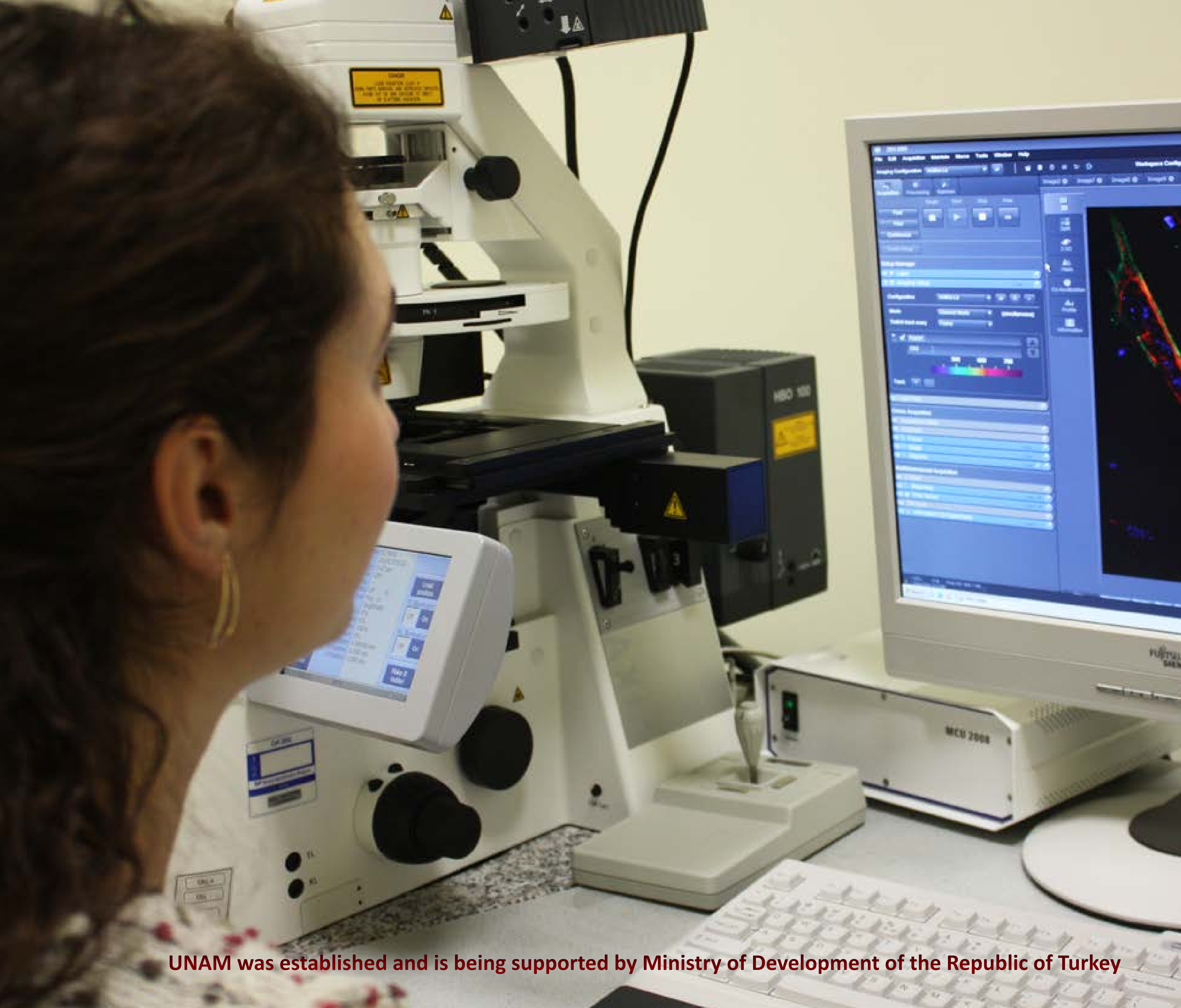
Bilkent University

unam

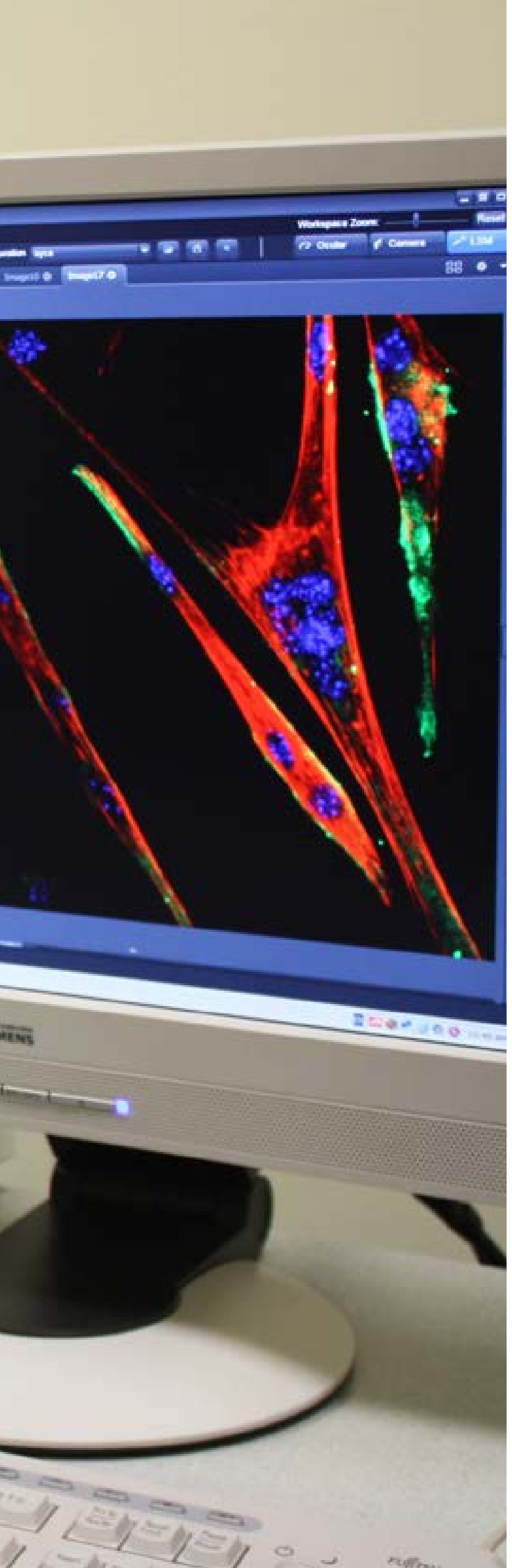
National Nanotechnology Research Center

Institute of Materials Science and Nanotechnology

ANNUAL REPORT 2013



UNAM was established and is being supported by Ministry of Development of the Republic of Turkey



CONTENT

RECTOR'S MESSAGE

Abdullah Atalar

Founded as the first private university of Turkey in 1984, Bilkent University has endeavored to serve as a world-class research university since its inception. This aspiration has been amply met by our university, which has been ranked among the world's top 100 universities for engineering and technology. One important hallmark of a research university is the establishment of specialized research centers. UNAM (National Nanotechnology Research Center), founded in 2006 under the leadership of Prof. Salim Çıracı and with the financial support of the Ministry of Development as Turkey's first national research center, has rapidly established itself as the most prominent nanotechnology-focused academic institution in the region. Cutting-edge research projects, overseen by a team of world-renowned scientists and highly accomplished graduate students, has since become the standard of academic excellence at UNAM. The state-of-the-art equipment facilities present at UNAM currently serve over 800 researchers from Turkey and nearby countries. As a steadfast supporter of collaborations between industry and academia, UNAM also leads several projects in tandem with industrial partners. UNAM researchers and graduate students have also created industrial applications of their scientific discoveries under 13 start-up companies.

A young and dynamic center, UNAM has recently completed its establishment process and looks forward to a healthy level of growth in the upcoming years, further substantiating its reputation as an national center renowned worldwide for its academic accomplishments.

DIRECTOR'S MESSAGE

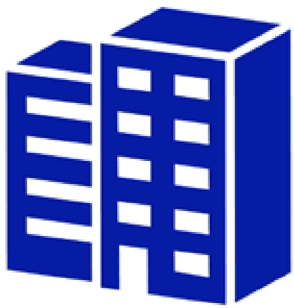
Mehmet Bayındır

UNAM's mission is to shape the future by expanding the limits of science and technology, utilizing its resources and technical prowess as a national center to develop technologies that will play important roles in our daily lives, as well as to raise well-educated scientific personnel to ensure the continuity of Turkey's technological and scientific development.

The UNAM Model: Rationale of a National Center

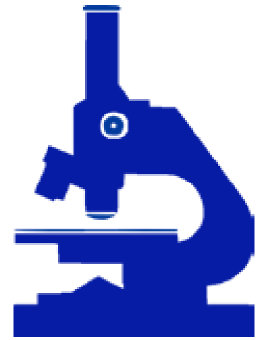
- Targeted research
UNAM is devoted to the advancement of nanotechnology, a field expected to singlehandedly define the major scientific accomplishments of the 21st century
- World-renowned researchers and experts
A dynamic team of academic personnel from distinguished research establishments
Minimal course loads, heightened emphasis on research, merit based salary
- Accomplished graduate students
Brilliant young scholars from a wide variety of disciplines
Successful international students
- Cutting-edge research infrastructure
Advanced equipment for interdisciplinary research, available 24/7 for all researchers in Turkey and surrounding countries
- A grant-based research system
Research funded through government grants and other external sources
Student stipends supplied through project grants
- Publications in high-impact journals
- Strong industry collaboration
Industrial applications of blue-skies research
Breakthrough findings patented for industrial use, establishment of spin-off companies

UNAM WITH NUMBERS



9000 m^2 total laboratory space

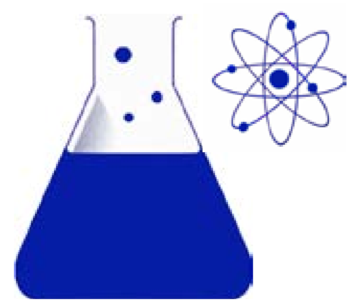
$35 million investment



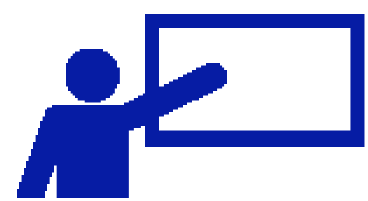
62
laboratories

Being a center of excellence in nanotechnology, UNAM conducts high caliber research and also trains highly qualified personnel. UNAM’s research findings are published on very high impact journals. UNAM also hosts over 800 external users from academia and industry and serves as a hub for exchange of information. UNAM organizes regional and international workshops to create a platform for dissemination of knowledge.

over $25 million
running research budget



48
active projects



13
workshops organized and hosted

256 researchers

- 25 faculty
- 16 scientists
- 25 post-docs
- 161 graduate students
- 25 engineers
- 4 staff

800 users

- 550 from academia
- 250 from industry

over 450

high impact journal articles in the last 5 years

13

spin-off companies

24

patents

52

awards

68

alumni

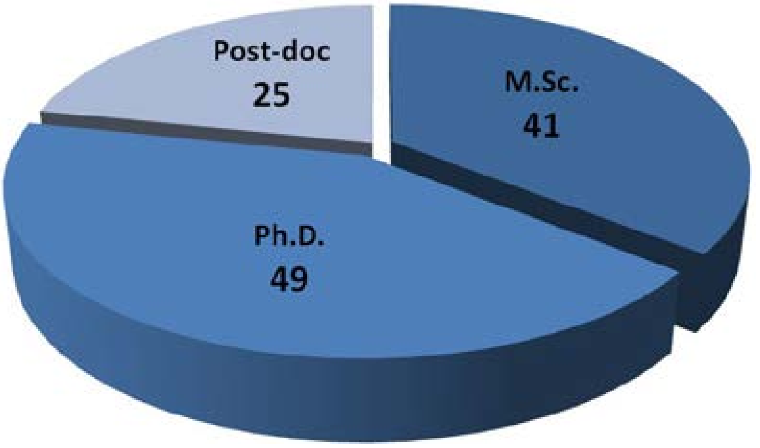
EDUCATION

In addition to its intense research programs, UNAM is also dedicated to train future scientific nanotechnology/nanoscience workforce of Turkey. Currently, Material Science and Nanotechnology (MSN) Graduate program is accepting students from top ranking national and international institutions. Successful students from various backgrounds have been accepted to the MSN programs to pursue research leading to Master of Science and Doctorate degrees. One important aspect that brings richness to the program comes from its interdisciplinary nature, which also increases the interaction of the students from various disciplines resulting in creating a common scientific language for nanoscience and nanotechnology. UNAM is providing students an opportunity to work with state-of-the-art instruments to tackle important problems of nanotechnology.

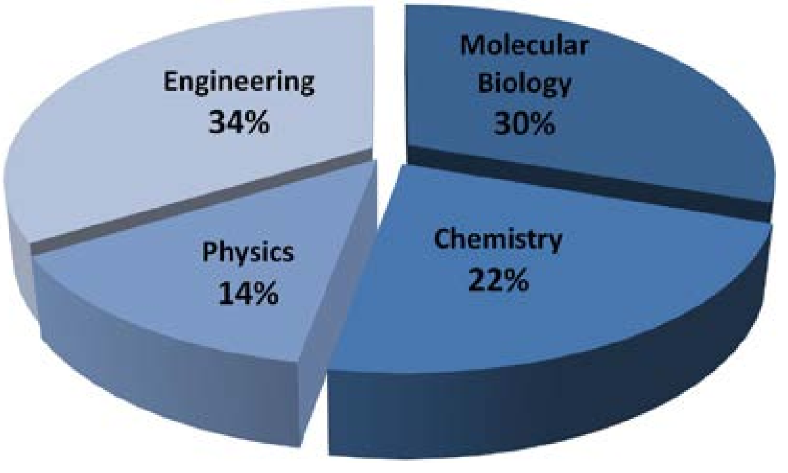
MSN curriculum has a rich variety of courses from physical sciences, chemical sciences and life sciences as well as engineering sciences. MSN program accepts students from different backgrounds. Multi-disciplinary MSN program is designed to encourage the students to learn different subjects towards developing ideas at the interface of physical/chemical and life sciences with a focus of engineering approaches.

MSN program also provides an opportunity to the students to develop a common language between different scientific backgrounds towards problem solving and generation of novel technologies.

As of 2013, MSN program has 49 Ph.D. students, 41 M.Sc. students and 25 post-docs. The students have a wide variety of backgrounds spanning nearly all engineering fields (34%) and fundamental sciences (66%). UNAM is a meeting point for individuals who are seeking a multidisciplinary and multinational learning environment.



Distribution of MSN students and post-docs



MSN students are accepted from a wide variety of disciplines

Course Code	Course Name
MSN 500	Concepts in Materials Science
MSN 501	Atomic Structure, Mechanical and Thermal Properties of Materials
MSN 502	Nanoscale Materials and Nanotechnology
MSN 503	Quantum Mechanics for Materials Science I
MSN 504	Phase Transformations and Diffusion in Materials
MSN 505	Fundamentals of Thin Film Materials
MSN 506	Experimental Methods in Applied Physics
MSN 507	Electrical, Optical and Magnetic Properties of Materials
MSN 508	Quantum Mechanics for Materials Science II
MSN 509	Statistical Thermodynamics
MSN 510	Imaging Techniques in Materials Science and Nanotechnology
MSN 511	Surface Science and Spectroscopy
MSN 512	Biomedical Materials
MSN 513	Micro and Nanostructured Sensors
MSN 515	Nanotechnology in Agriculture and Food
MSN 517	Fundamentals of Nanoscience
MSN 518	Fundamentals of Nanotechnology
MSN 521	Biotechnology
MSN 532	Selected Topics in Materials Science and Nanotechnology
MSN 534	Characterization of Polymeric Materials
MSN 535	Textile Materials
MSN 541	Nanobiotechnology
MSN 543	Protein and Gene Engineering
MSN 551	Introduction to Micro and Nanofabrication
MSN 555	Nanomaterials Processing by Intense Laser Beam
MSN 590	Seminars in Materials Sci. & Nanotechnology: Technology Development
MSN 591	Nanotechnology and Its Impacts on Socio-Economic Structures
MSN 598	Seminar I
MSN 599	Master's Thesis
MSN 601	Advanced Computational Nanoscience
MSN 698	Seminar II
MSN 699	Ph.D. Thesis

UNAM ALUMNI

UNAM graduates continue their careers at world's leading universities or start industrial careers at high caliber companies. Below is a selected list of UNAM alumni and their current positions. UNAM is always proud of its alumni. Thanks to the world class education provided at UNAM, our alumni are well sought after in academia and industry.

Name	Current Institute	Current Position
Yusuf Çakmak	Manchester University	Post-doctoral Associate
Sündüs Erbaş Çakmak	Manchester University	Post-doctoral Associate
Hasan Şahin	University of Antwerp	Post-doctoral Associate
Hülya Budunoğlu	Aselsan	Project Engineer
Oya Ustahüseyin	Max Planck Institute	Ph.D. Student
Pınar Angün	Eti	Project Engineer
Sıla Toksöz	Biyonesil	Co-founder
Tural Khudiyev	Bilkent University	Post-doctoral Associate
Onur Büyükçakır	KAIST	Post-doctoral Associate
Bülent Öktem	Aselsan	Project Engineer
Shabab Akhavan	Northwestern University	Ph.D. Student
Murat Kılınç	Rockefeller University	Research Intern
Gökçe Küçükayan Doğu	Bilkent University	Post-doctoral Associate
Ruslan Guliyev	Bilkent University	Post-doctoral Associate
Yasemin Coşkun	Arçelik	Project Engineer
Kıvanç Özgören	Start-up	Entrepreneur
Mecit Yaman	University of the Turkish Aerospace Association	Associate Professor
Seymur Cahangirov	European Theoretical Spectroscopy Facility	Post-doctoral Associate
Mehmet Topsakal	University of Minnesota	Post-doctoral Associate
Hüseyin Duman	Roketsan	Project Engineer
Muhammet Çelebi	TÜBİTAK Uzay	Project Engineer
Mert Vural	Carnegie Mellon University	Ph.D. Student
Handan Acar	University of Iowa	Post-doctoral Associate

A WORD FROM THE ALUMNI

I feel privileged by completing my graduate degree at UNAM. I have worked on sophisticated theoretical and numerical solid state problems. UNAM provides students a unique environment by bringing together several experts from a wide variety of disciplines. This multidisciplinary research environment fosters the high achieving atmosphere. UNAM's highly motivated researchers have encouraged me throughout my studies. I have taken several courses that have broadened my vision such as solid state physics, quantum mechanics, statistical physics, group theory, nanophotonics, nonlinear dynamics and chaos theory. The cutting edge projects I have worked on has enabled me to apply this know-how on the problems that I have tackled. I believe UNAM is soon to be one of world's leading research institutions by the extensive and motivating research environment it provides.

Dr. Seymur Cahangirov

I am one of the very first students and Ph.D. graduates of UNAM. After I have completed my Ph.D. at UNAM in 2012, I have joined University of Minnesota Chemical Engineering and Materials Science Dept. as a post-doctoral associate. Experiencing the research environment abroad, I can say that UNAM is significantly contributing to advancement of science in Turkey and across the world. Several researchers I met at USA expressed their admiration to UNAM. UNAM is also serving Turkey by attracting leading scientists all across Turkey.

Dr. Mehmet Topsakal

I completed my master's and doctorate degrees at UNAM between 2007 and 2013. UNAM is a visionary institution with its technical capability and the researchers it houses. I believe the young and talented researchers of UNAM will soon be the role model for Turkey's leading research institutions.

Dr. Sündüs Erbaş Çakmak

I have received my Ph.D. degree from UNAM with my thesis on fiber lasers. At UNAM, I have gained expertise on fiber laser theory, design, ultrahigh speed nonlinear optics, high power laser systems and their applications on material processing, metrology, defense and health. The world class infrastructure of UFOLAB and UNAM enabled me to develop a large skill set on fiber lasers and their applications.

Dr. Kıvanç Özgören

I have been in United States for more than a year. I found opportunities to visit many universities and research centers. I can proudly say that, I have barely seen the resources such as in UNAM. In many universities, the lack of the sources and/or high charges of devices are the main problem. I have bewitched many people by talking about UNAM and 24/7 access to almost all of the devices, which were in very high quality. Without a doubt; the quality of the devices, ease of access and able to learn from the experts, is nothing but the pieces of art of perfect science.

One occasion that I miss the most is the scientific discussion that we were having with my friends from many different backgrounds even during lunch or the way home. The scientific ambiance of UNAM, makes science a life style, not a job. As a result, when you graduated, and appear on the stage, you are able to do your job with confidence of the knowledge that you have had with the respect that you have learnt from the high quality professors of UNAM.

Dr. Handan Acar

I have witnessed the construction and establishment of UNAM since 2007, when I joined Bilkent University. The financial contribution of the Ministry of Development together with the enthusiasm of dedicated researchers enabled the foundation of such a unique center.

I was only able to work for one year at UNAM at the beginning of my graduate studies. Later on, in 2013, I have again worked at UNAM as a post-doctoral fellow under the supervision of Dr. Hilmi Volkan Demir. The extensive infrastructure of UNAM helped me complete my experimental studies in 8 months and publish my findings on a high impact journal. The two working periods that I had at UNAM made it very clear that UNAM has come along a long way in such short amount of time.

I would like to thank one more time to everybody who has contributed to the establishment of UNAM.

Dr. Gökçe Küçükayan Doğu

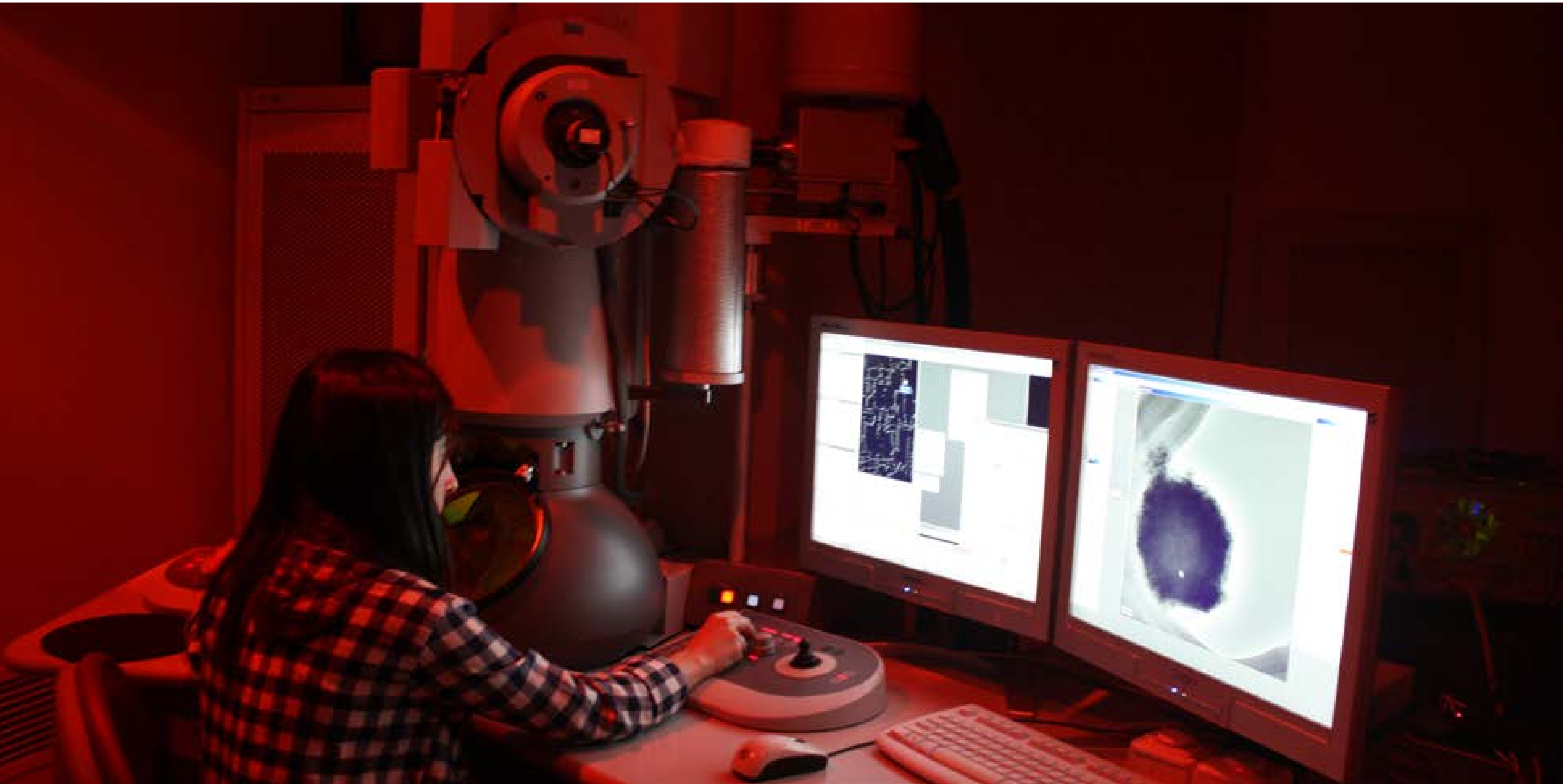

Electro-Spin100
unam

INFRASTRUCTURE

UNAM infrastructure has been developed over years to satisfy the needs of researchers from universities and institutions in Turkey and neighbouring countries. UNAM provides access to specialized instruments and enable researchers to carry out experiments through the guidance of highly qualified technical personnel.

UNAM infrastructure is very well developed and maintained regularly to satisfy the need of researchers. All UNAM equipments are listed on our website. The details, accessories and the contact person for all equipment are also provided on the website. These equipment are available to all internal and external users. In order to use these equipment, the users refer to the UNAM information system portal, UNAM-IS. After they receive their user password, the users can log in and monitor the availability of the equipment and reserve it accordingly.

As UNAM, we aim to continually improve our facility and maintain it to serve the users as best as we can. In 2013, the device down times was kept below 5% thanks to the dedication of our technical personnel and the users.



Imaging / Microscopy

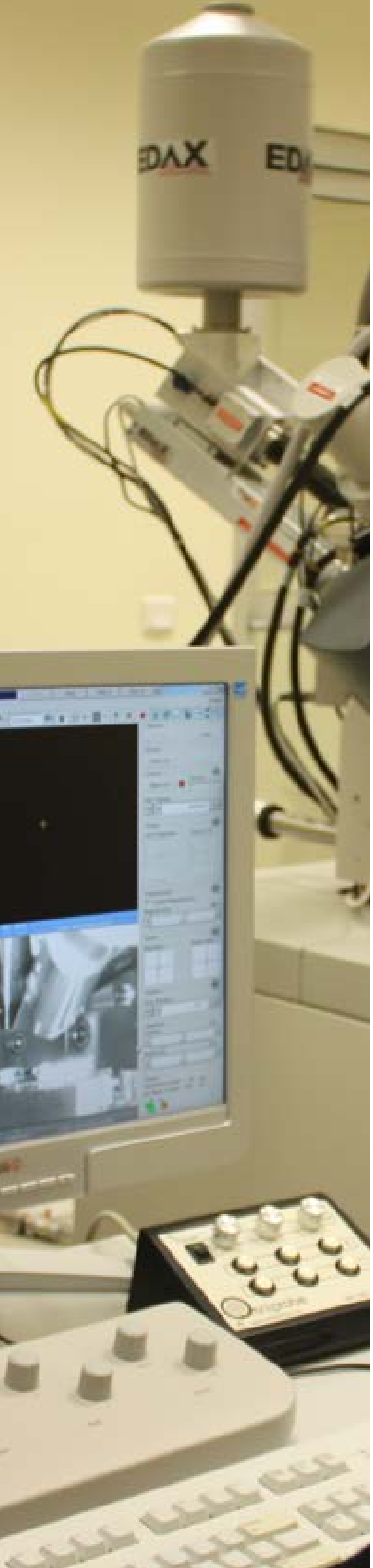
Atomic Force Microscope (AFM, PSIA)
Atomic Force Microscope (AFM, Asylum)
Confocal Microscope
Dual Beam
E-Beam Lithography (E-BEAM)
Environmental Scanning Electron Microscope (ESEM)
Fluorescent and DIC Equipped Upright Microscope
Fluorescent and DIC Equipped Inverted Microscope
Material Microscopes
SNOM + 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
Fluorospectrometer
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)

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



Material synthesis / Characterization

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

Cleanroom

Asher
Atomic Layer Deposition (ALD, Fiji)
Atomic Layer Deposition (ALD, Savannah)
Autoclave
Critical Point Dryer
Dicing Saw
E-Beam Evaporation
Electroplating Station
Hot Plates
Inductively Coupled Plasma (GaN, GaAs)
Inductively Coupled Plasma (Si)
Low Pressure Chemical Vapor Deposition (LPCVD)
Mask Aligner
Mask Aligner with Nanoimprint Lithography
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
Stylus Profilometer
Thermal Evaporators
Wet Benches
Wire Bonders
XeF_2 Etcher

Biotechnology

- Bioreactors (2 lt / 5 lt / 30 lt)
- Centrigures / Microfuges / Ultracentrifuges
- Cold Room
- Cryostat
- Electroporator
- -80 Freezers
- Gel Imaging and Documentation System
- Gradient PCR
- Gradient Real-Time PCR
- Laminar Flow Cabinets
- Microplate Reader
- Microtomes
- Osmometer
- Shaking Incubators
- Sterile Cabins
- Vibratome

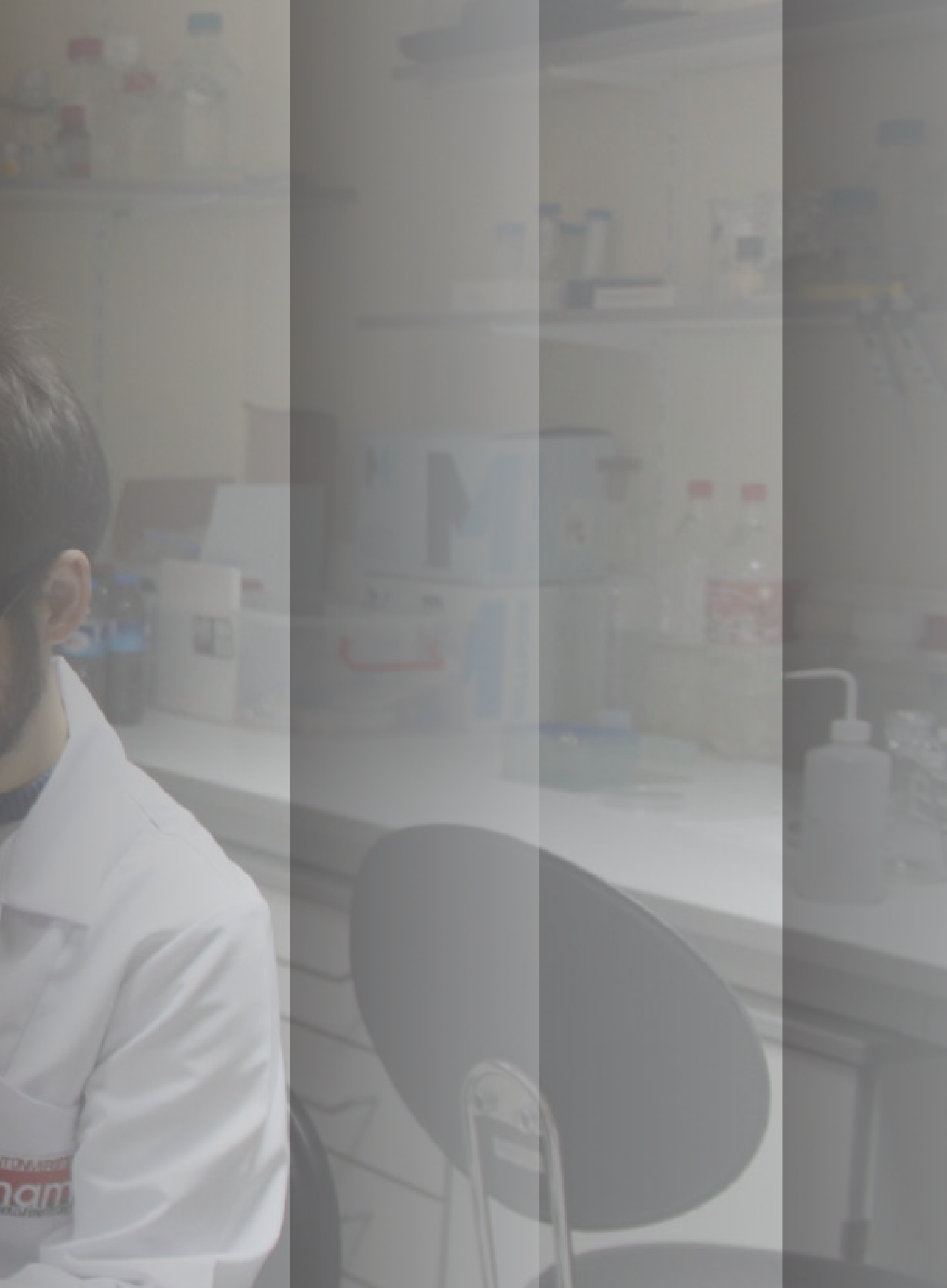
Fiber production / Characterization

- Fiber Draw Tower
- Fiber Draw Tower (High temperature up to 2300 ^{o}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 (1200 ^{o}C)
- Ultrasonic Drill
- 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

CONTRIBUTIONS TO INDUSTRY AND ACADEMIA



PARTNERSHIP WITH INDUSTRY

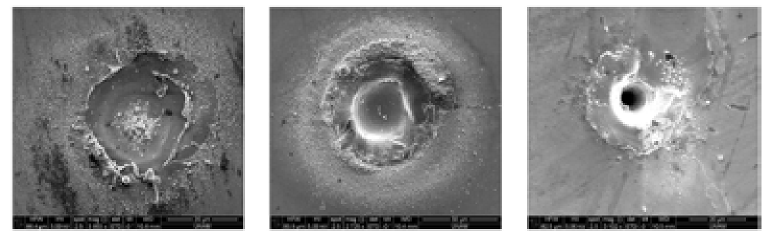
UNAM researchers have a strong ability to manage interdisciplinary projects and also meet the expectations of industrial partners. UNAM researchers contribute to industry by tackling technological problems with scientific and innovative solutions. SMEs and large organizations build a strategy for success by working together with UNAM researchers.

Besides collaborative projects, UNAM supports industrial organizations by providing them well maintained infrastructure. UNAM's 400 m² clean room comprises class 10, 100 and 1000 areas and state of the art equipment. UNAM's characterization laboratories are continuously expanding with additional equipments. Despite its short history, UNAM currently hosts around 250 researchers and several research groups. The number of users from universities has reached over 550 in addition to the 250 UNAM users from industry. The facility and all the equipment are managed through an online reservation system. The equipments are available 24/7 and qualified users can have access the required instruments at any time through the online reservation system. First time users can benefit from the qualified technical personnel available at each laboratory. The users can receive comprehensive hands-on tutorials and guidance from the dedicated personnel.

List of the companies utilizing UNAM infrastructure

Akzo Nobel Boya
Arıteks Boyacılık
As İnşaat
Aselsan
Bayrak ARGE
Biyotez Makine Kimya
Bilkent Cyberpark
Deltamed Yaşam Bilimleri
Dizayn Teknik Boru ve Elemanları
Drogsan İlaçları
DYO Boya Fabrikaları
E-A Teknoloji Biyomedikal Cihazlar
Eczacıbaşı Holding
Embil İlaç
Ermaksan Makine
Eti Maden İşletmeleri
Genamer Teknoloji
İKSA Mühendislik
Kordsa Global Endüstriyel İplik
Kordsa
Korozo Ambalaj
Maden Tetkik ve Arama Enstitüsü
MAN Türkiye
Meteksan Savunma
Mikron Makine
Mono Kristal Teknolojileri
Nanodev
Norm Tıbbi Ürünler
Nurol Teknoloji
Paşabahçe Cam
Plant Tıbbi Malzemeleri
PMS Medikal
Roketsan
Sanko Holding
Şişecam
Gapso Soğutma
Teksel ARGE
Tepe Betopan
TÜBİTAK Marmara Araştırma Merkezi
Virosens Medikal

ATEL Technology & Defence Industry Co.



ATEL and UNAM have been working together to develop an optical sensor destruction system from long range by using high power fiber laser technology. Optical sensor systems are used to monitor or determining the location, speed and possible route of a target. The mission of the power fiber laser system is to form temporary or permanent destruction on optical sensor systems. The fiber laser system is designed to be user friendly and produce high quality light with low cost for the military applications. The Yb-doped fiber laser system planned to be developed in UNAM-Laser laboratory will operate in continuous regime. This important and critical technology that is used by many sectors in foreign countries is brought to our country with scientific facilities, experienced personnel and industrial applications. The picture demonstrates the damage given to a semiconductor active area of sensor at increasing laser power.

Hemosoft Bilişim

Hemosoft and UNAM recently started cooperating in order to develop the next generation point-of-care diagnostic platform. Hemosoft is a leading company in Turkey, specialized in software development for blood bank management, blood and organ transfusion. In addition, Hemosoft is developing several innovative biomedical products. Hemosoft and UNAM are collaborating to develop a portable platform for detection of cardiac markers for early diagnosis of myocardial infarction.

Healthcare technologies are going through a revolution with innovative products coming into the market with an emphasis of self-monitoring. Combining these technologies with the rapidly evolving smart phone devices is building the future of the medical industry which aims for personalized medication. Close and early monitoring is the most critical component of personalized health treatment. Therefore, portable diagnostic systems have an ever increasing role in our lives. Hemosoft and UNAM are bringing their expertise together for development of such products which will position Turkey high in this emerging market.

BSH - Bosch and Siemens Household Appliances

As BSH, we truly believe in the neccessity of cooperation of industry and academic institutions in order to process the know-how to turn into marketable products. We work with several research institutions through different business models. Amongst them, our cooperation with UNAM will certainly be a role model for every organization aiming for development of revenue generating innovative products.

Together with UNAM, we have worked on functional surface coatings to improve our already existing product line. We have developed easy-to-clean and water repellent surface coatings for household appliances. The surprisingly successful results encouraged us to further develop our partnership with scientific organizations.

Murat Yücel

Nanobanknote Project with Central Bank Banknote Printing Plant

As with many other industries, nanotechnology is expected to have a significant impact on the pro¬duction and processing of paper. Run in tandem with the Central Bank of Turkey, the nanobanknote project aims to evaluate the potential utility of nanotechnology in the production, safety and daily use of banknotes and negotiable instruments, and has created a detailed roadmap for the implementation of such technologies. In accordance with this roadmap, upcoming projects are to focus on various im¬provements in the banknote production process, including the use of nanocoatings to lengthen the life¬time of banknotes, signature odours to ease banknote handling for the visually impaired, color-chang¬ing ability to hamper counterfeiting attempts, flexible electronic circuits for increased security and femtosecond laser systems for the enhancement of the banknote printing process.

Banknote carrying a distinctive rose odour allows visually impaired citizens to better handle their currency. Molecules imparting the odour have been deposited within nanofibers and diffuse slowly by a controlled release process that ensures that the rose odour lasts for years.

Dr. Mehmet Bayındır / Project Coordinator

UNAM SPIN-OFFs

The role of high-technology, revenue producing products has been realized by all countries. As being the first nanotechnology research center of Turkey, UNAM carries the goal of contributing to the development of game changing innovative products. The multidisciplinary environment at UNAM fosters such technological leaps. In addition, the close proximity of incubation centers such as Bilkent Cyberpark, METU Technopolis and Hacettepe Technopolis provides the collaborative ecosystem for companies utilizing the UNAM infrastructure. In addition, this environment leads to several spin-off companies. A list of UNAM spin-off companies are given below.

Company Name

Yeni Bilge Nanoteknoloji

IPS Ankara Tekno Bilişim Ar-Ge

Auron Teknoloji

Niser

Nanosens

Deber

E-A Nanoteknoloji

Nanobiyoteknoloji

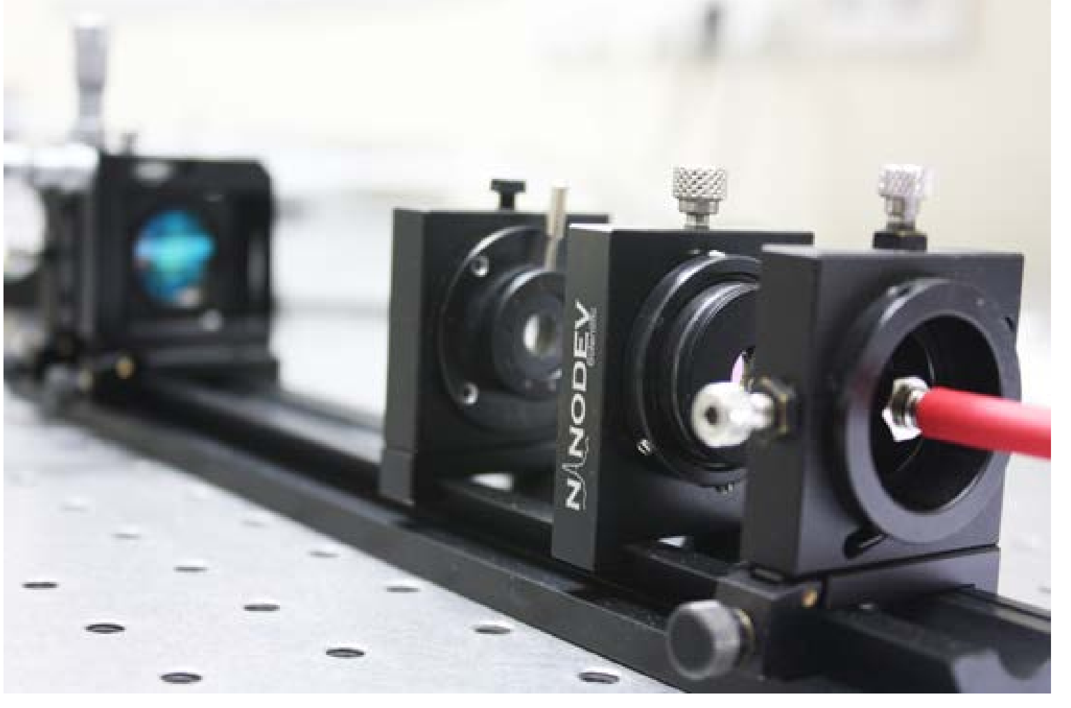
SY Nanoboya Teknoloji

EA Teknoloji

Nanodev

Okyay Enerji

Biyonesil



Nanodev Scientific

Okan Öner Ekiz
Nanodev Scientific, CEO

Nanodev Scientific is a spin-off company that manufactures advanced optical and biomedical characterization devices. Nanodev has revenue on 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 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 cutting edge technology into daily life. Most promising project of Nanodev is a device that makes it is possible to detect series diseases at home. Image being able to touch a small device and instantly get back whether you have key markers for a heart attack or an infectious disease. Such early detection tools are some of the innovative products that Nanodev is developing.

SEIS V. National Medical Instrument Contest
1st Prize Winner

ANKARA
YENİLİKÇİ ANKARA PROJE PAZARI

Most Promising
Company Award

Ministry of Science
and Industry
2012

EA Teknoloji

The main business areas of EA Teknoloji are nanotechnology and biotechnology. The company was started with the support of the Ministry of Industry and Trade and specialized in high-tech projects using scientific approaches to realizing the technological problems, fast, affordable and professional solutions. EA Teknoloji focuses on the production and R&D activities of the followings:

- Custom manufacturing of micro-and nanofabrication design and applications
- High power and resolution of industrial laser applications (micro-and nano-level material processing, micro labeling)
- Design and production of thin-film optical insulation and filtration systems.
- Fields of activity-related projects (nanotechnology, optical systems, biotechnology), scientific and technical consulting services.

UNAM USERS ALL ACROSS TURKEY

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

Since its establishment, UNAM has been serving many 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 UNAM users.

UNAM is accessible to all researchers. Currently there are more than 800 users of UNAM. Located in Ankara, UNAM is accessible to all researchers across Turkey. Currently, researchers from 74 different universities are actively utilizing UNAM. Users indicate that they are very satisfied with the research intensive environment provided at UNAM. It is not only the infrastructure, but also the joint know-how the researchers and the technical personnel that help users excel in their research.

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.

List of the universities utilizing UNAM infrastructure

Abant İzzet Baysal University
Adnan Menderes University
Afyon Kocatepe University
Akdeniz University
Aksaray University
Amasya University
Anadolu University
Ankara University
Atatürk University
Balıkesir University
Başkent University
Beykent University
Bilecik Şeyh Edebali University
Bilkent University
Boğaziçi University
Bozok University
Bülent Ecevit University
Celal Bayar University
Cumhuriyet University
Çanakkale Onsekiz Mart University
Dicle University
Dokuz Eylül University
Ege University
Erciyes University
Erzincan University
Eskişehir Osmangazi University
Fatih University
Fırat University
Gazi University
Gaziosmanpaşa University
Gebze University
Gebze Institute of Technology
Gülhane Military Medical Academy
Hacettepe University
Hitit University
İnönü University
İstanbul University
İstanbul Technical University
İzmir Katip Çelebi University
İzmir Institute of Technology
Kafkas University
Kahramanmaraş Sütçü İmam University
Karabük University
Karadeniz Technical University
Kırıkkale University
Kocaeli University
Koç University
Marmara University
Masdar Institute of Science and Technology
Melikşah University
Middle East Technical University
Muğla Sıtkı Koçman University
Mustafa Kemal University
Namık Kemal University
Niğde University
Ondokuz Mayıs University
Ordu University
Özyeğin University
Pamukkale University
Sabancı University
Sakarya University
Selçuk University
TED University
TOBB University of Economics and Technology
Trakya University
Turgut Özal University
University of Mosul
University of Baghdad
University of Tehran
University of Turkish Aeronautical Association
Yazd University
Yeditepe University
Yıldırım Beyazıt University
Yıldız Technical University

TOTAL: 74 Universities

FEEDBACK FROM THE USERS

We have been using the equipment available at National Nanotechnology Research Center for a few years. Specifically, we are regularly using the high resoultion mass spectrometer. The quality service we are getting from UNAM is significanlty adding to the value of our research.

The challenges we face during the measurements are tackled with the help of UNAM's generous staff. We are very glad to work with you. We wish other universities to take UNAM as an example as a shared user facility.

Prof. Dr. Metin Balcı
Middle East Technical University

BİYOTEZ
MAKİNE KİMYA AR&GE DANIŞMANLIK

We have used UNAM facilities for nanoparticle size characterization using Zetasizer. We would like to thank the UNAM staff deeply for their professional attitude. With their help, we were able to get a very detailed analysis in short amount of time. The fact that we can access to the equipment at UNAM at utilize them very effectively, gives us confidence in pursuing innovative approaches.

Dr. Ş. Tolga Çamlı
Ar&Ge Director

BIYOTEZ
Makine Kimya Ar&Ge Danışmanlık
San. ve Tic. Ltd. Şti.

I have met UNAM in 2008 during a TÜBİTAK project I was leading. I have used UNAM infrastructure during this project. Later on my students have used UNAM clean room on several occasions.

I would like to express my gratitude to all researchers who took part in establishment of UNAM. The idea of shared equipment is revolutionary for Turkish universities. UNAM plays a leading role in developing know-how and sharing it with all its users.

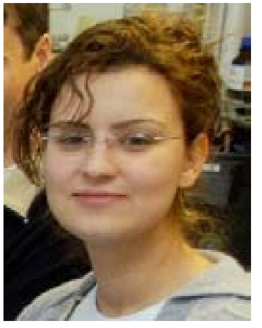
We take UNAM as a role model when we are establishing the Advanced Technology Research Laboratory at Erzurum Technical University. Similar to UNAM, we are aiming to be a technology hub in our region.

Prof. Dr. Bülent Çakmak
Vice Rector
Erzurum Technical University

We have been using the high resolution mass spectrometer in order to analyze our samples. We are very satisfied with the service provided during the sample preparation and the analysis. We would like to stress that we are very impressed with the dedication of the technical and administrative personnel at UNAM.

Prof. Dr. Metin Zora
Middle East Technical University

I have been working at UNAM in the scope of my TÜBİTAK 3501 project, titled "Development of an optical nanosensor with metal nanoparticles for the detection of cancer antigen 125 (CA125)". I have used several equipments at UNAM including X-ray photoelectron spectrometer, Fourier Transform IR Spectrometer, UV-VIS Spectrometer, Raman Spectrometer and Scanning Electron Microscope. The fact that I can access to all these equipments in a single facility has been a great benefit for my studies. Besides UNAM infrastructure, I should also mention the knowledgeable staff that UNAM has provided me all the technical support I need.



Asst. Prof. Dr. İlknur Tunç
University of Turkish Aeronautical Association

We have been collaborating with UNAM groups for more than four years. In addition, we have used UNAM infrastructure on several occasions. UNAM is unique in Turkey, in the sense that the infrastructure is very well maintained and is very easily accessible to researchers all across Turkey.

We are also very proud of the world-wide accomplishments of UNAM researchers. I would like to thank you for the support and services you have been providing.

Assoc. Prof. Dr. Selçuk Aktürk
İstanbul Technical University

I have been using the facilities of National Nanotechnology Research Center (UNAM) since 2011. Some of the equipments that I have been using are Physical Property Measurement System (PPMS), Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM), Raman Spectrometer, Fourier Transform IR Spectrometer, X-ray Electron Spectrometer, X-ray Diffraction Spectrometer, Differential Scanning Calorimetry and Thermogravimeter. The quality of the service we have received enabled us to reach very interesting conclusions in our studies and publish our findings in international high impact research journals.

The online reservation system, UNAM-IS, is very helpful for us to plan our studies beforehand. My students were able to coordinate their needs with UNAM personnel very easily. I won't be exaggerating saying that UNAM is a technology center that provides world-class high quality service.

Asst. Prof. Dr. Hatice Duran
TOBB ETU University

We have used UNAM cleanroom for mask writing and photolithography. We were able to rapidly analyze our sample using Transmission Electron Microscope. We would like to express our appreciation to everybody keeping the UNAM infrastructure available for all researchers. UNAM is certainly an enabling center for our studies.

Asst. Prof. Dr. Harun Kaya
İnönü University

My project application has been approved immediately, my registration to the device reservation system has been completed within half an hour and I have been able to do my measurements with the support of academic staff. With the data that I acquired at UNAM, I am going to return to MIT and continue my PhD in Cambridge, MA. Being able to do science rapidly, owing to UNAM's effective and fast system, is a great opportunity and a key asset for Turkey. UNAM's effective administration is also a good example for all academic institutions around the world, including the established universities.

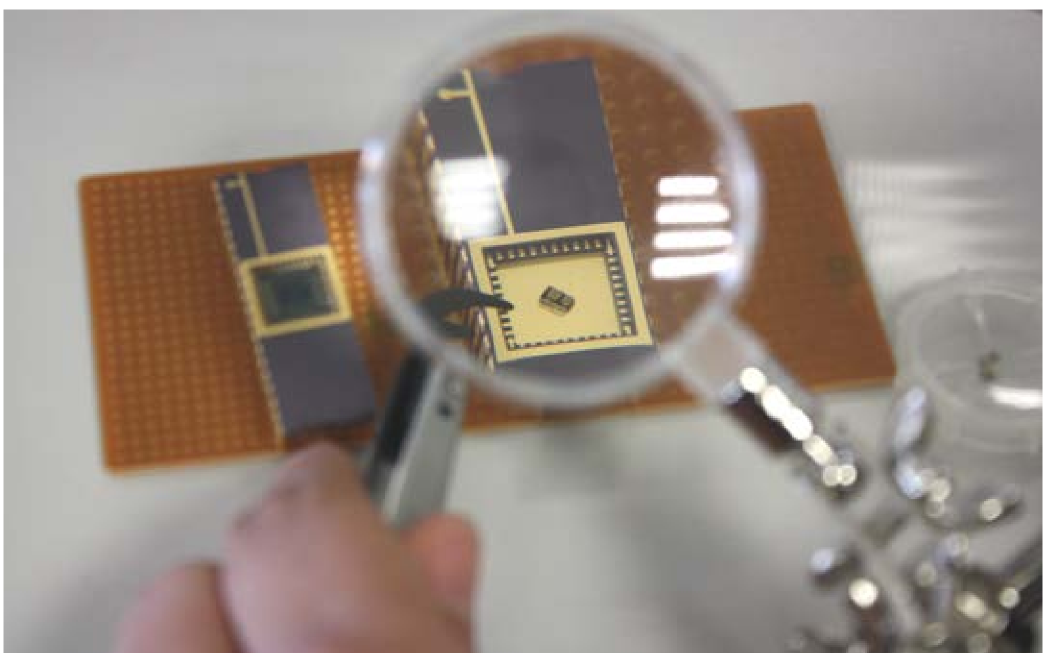
Mehmet Cengiz Onbaşlı
Ph.D. candidate, MIT

RESEARCH HIGHLIGHTS

UNAM has demonstrated striking achievements in terms of its scientific output despite its young age. UNAM researchers have published their findings at very high impact scientific journals such as Nature Materials, Nature Photonics, Nano Lettters, Angewante Chemie, Advanced Materials, ACS Nano, Lab on a Chip and Nanoscale.

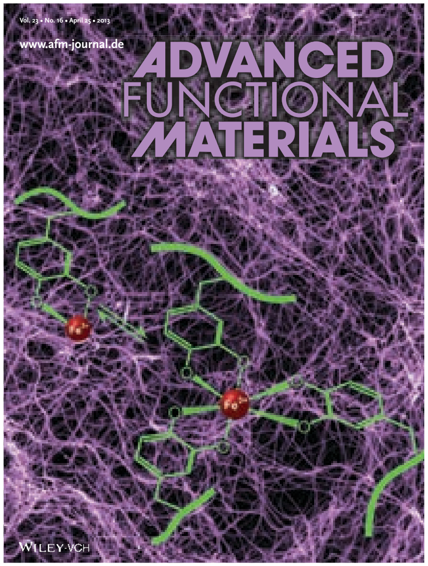
In addition to journal publications, some of UNAM's findings were recorded as international and national patent applications. The number of UNAM-based patents and the high-level publication track record of UNAM demonstrate its potential to be a primary hub for original contributions in the field of nanotechnology.

So far, UNAM has completed 47 projects whose total funding was over $32 million. As of December 2013, there are 48 active projects running at UNAM with a total budget of around $25 million. Through these projects, UNAM has established a world-class infrastructure and trained over 300 highly qualified experts. Also, establishing an online reservation system, UNAM-IS (information system), the facility was made available 24/7 to external users.



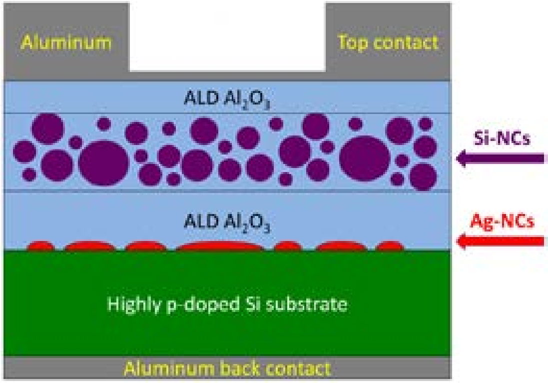
Supramolecular polymers

A supramolecular hydrogel network is held intact through noncovalent interactions among low-molecular weight building blocks. The intermolecular interactions among the building blocks are important for stimuli-responsive modulation and self-healing properties. A mussel-inspired metal ion coordination into the supramolecular polymer network is shown to be advantageous for improving mechanical properties as well as retaining original properties of the network. In order to circumvent this challenge without losing the original benefits of reversibility and self-healing qualities, researchers from Bilkent University and National Nanotechnology Research Center (UNAM) of Ankara described a mussel adhesion inspired method for supramolecular peptide nanofiber gels.



Dr. Güler and his co-workers applied a pH-dependent, iron-mediated crosslinking mechanism to self-assembled peptide hydrogel network. They show that triscatecholate formation inside the supramolecular network significantly enhances mechanical properties to a level comparable to covalent crosslinking of the same network. This strategy possesses not effect on the β-sheet-driven self-assembly process; therefore, the supramolecular architecture is preserved. Remarkably, the network retains its pH-dependent reversibility and self-healing properties upon a high shear load. These two properties are almost entirely lost in covalently crosslinked hydrogels. The authors propose Dopa-mediated cross-linking strategy can further be applied to a broad range of supramolecular systems, through which mechanical properties can be reversibly controlled.

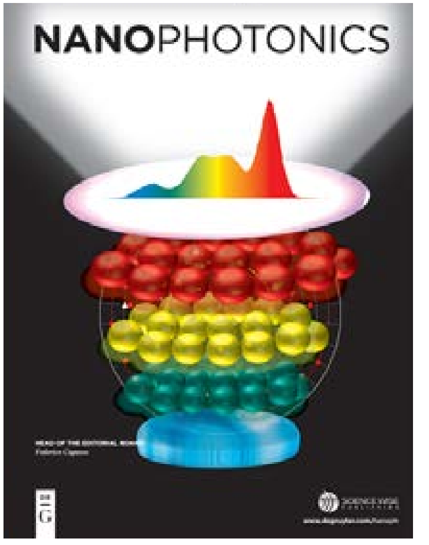
Plasmonic enhanced photodetectors based on semiconductor nanocrystals



Dr. Okyay's research group has been working on realizing ultra-low cost optoelectronic devices using nanoparticles. His group demonstrated a photodetector based on silicon nanocrystals (Si-NCs) synthesized using laser ablation technique. This innovative approach can produce 20-150 nm-sized silicon nanocrystals using laser ablation, which is potentially a low-cost and high-throughput method. (S. Alkis, F. B. Oruç, B. Ortaç, A. C. Koşger and A. K. Okyay: Plasmonic Enhanced Photodetector Based on Silicon Nanocrystals Obtained Through Laser Ablation. J. Optics 14, 125001 (2012)). This work is highlighted in Nature Photonics. It is believed that Si-NCs via laser ablation could be useful for creating a variety of other optoelectronic devices, such as flexible and disposable sensors and cost-effective solar cells.

This work on ultra low cost photodetectors was highlighted in Nature Photonics as Research Highlight (Nature Photonics 7, 2, 2013) doi:10.1038/nphoton.2012.348.

Color science of nanocrystal quantum dots for lighting and displays



Colloidal nanocrystals of semiconductor quantum dots (QDs) are gaining prominence among the optoelectronic materials in the photonics industry. Among their many applications, their use in artificial lighting and displays has attracted special attention thanks to their high efficiency and narrow emission band, enabling spectral purity and fine tunability. By employing QDs in color-conversion LEDs, it is possible to simultaneously accomplish successful color rendition of the illuminated objects together with a good spectral overlap between the emission spectrum of the device and the sensitivity of the human eye, in addition to a warm white color, in contrast to other conventional sources such as incandescent and fluorescent lamps, and phosphor-based LEDs, which cannot achieve all of these properties at the same time. Here we summarized the color science of QDs for lighting and displays, and presented the recent developments in QD-integrated LEDs and display research. Following a general introduction to color science, photometry, and radiometry, we presented the studies on spectral designs of QD-integrated white LEDs that have led to efficient lighting for indoor and outdoor applications. Subsequently, we discussed QD color-conversion LEDs and displays as proof-of-concept applications – a new paradigm in artificial lighting and displays.

UNAM team brings advanced spectroscopy to mobile phones

Spectroscopic analysis methods provide a great deal of information about material properties, but require complex optics and costly equipment. Recent research at UNAM suggests that mobile phone cameras may have what it takes to alleviate the costs. The research in question, conducted by Dr. Aykutlu Dâna and published in ACS Photonics, details the acquisition of Raman signals using the image sensor of a conventional smart phone, and the comparison of this information to these taken by standard detection equipment (a photomultiplier and a cooled CCD spectrometer). While the camera was no match for the sensors specialized for the job, it was nonetheless able to detect the Raman signals associated with silicon and ethanol, suggesting that it had the sensitivity necessary to carry out chemical component analysis using Raman spectroscopy – and indeed, when a collimator and a transmission grating were placed in front of the phone, the makeshift smart phone-spectrometer was able to resolve the spectral signatures. When the spectra were amplified using a signal-enhancing plasmonic substrate, the mobile camera proved even more capable, detecting the transitory signals (or “blink events”) that occur when a molecule briefly associates with the signal-enhancing regions of the plasmonic surface. These events allow the extraction of chemical information from single molecules, and have drawn much attention as a means to investigate the movement of an individual molecule. In tandem with the above-mentioned spectrometer set-up, the phone camera was capable of doing just that, at a frequency of 30 frames per second, in real time.

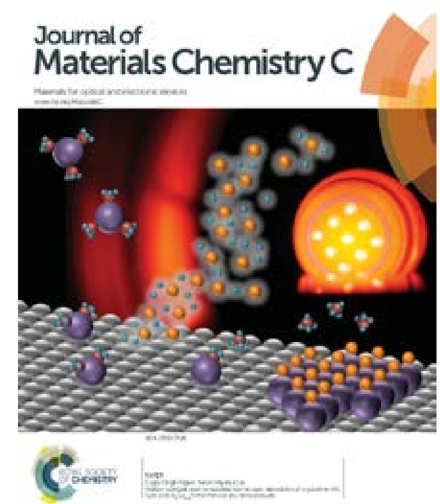
Dr. Dâna’s research not only serves as testament to the progress of mobile devices, but also facilitates the development of low-cost handheld equipments for chemical analysis of a diverse array of materials.

This work was also highlighted in Nature Photonics as Research Highlight (Nature Photonics 8, 168, 2014) doi:10.1038/nphoton.2014.30.

An optoelectronic nose that smells counterfeit alcoholic beverage

Industrial scale production of counterfeit alcoholic beverages is a growing worldwide problem causing serious health problems and, in many cases even death. In counterfeit alcoholic beverages, synthetic methanol, a highly toxic alcohol, is used instead of naturally fermentated ethanol. Differentiation of methanol adulterated beverages is a very challenging task for conventional artificial nose technologies for two main reasons; alcoholic beverages consist of many interfering volatile compounds, and ethanol and methanol are very similar in their physical and chemical properties (i.e. funcitonal groups, vapor pressure, molecular size etc.). A recent article published in Analytical Chemistry by Dr. Bayındır's group reports successful discrimination of methanol and ethanol in chemically complex environments taking advantage of highly selective optofluidic Bragg fiber arrays. With demonstrated superior sensor parameters and flexibility in sensor array design, this novel optoelectronic nose concept is a strong contender in emerging artificial nose technologies.

Hollow cathode plasma-assisted atomic layer deposition of crystalline AlN, GaN and $Al_xGa_{1-x}N$ thin films at low temperatures



III-nitride compound semiconductors and their alloys have emerged as versatile and high-performance materials for a wide range of electronic and optoelectronic applications. Although high quality III-nitride thin films can be grown at high temperatures (>1000°C) with significant rates, deposition of these films on temperature-sensitive device layers and substrates necessitates the adaptation of low-temperature methods such as atomic layer deposition (ALD). When compared to other low-temperature thin film deposition techniques, ALD stands out with its self-limiting growth mechanism, which enables the deposition of highly uniform and conformal thin films with sub-angstrom thickness control. These characteristics make ALD a powerful method for depositing films on nanostructured templates, as well as preparing alloy thin films with well-defined compositions. In this article, authors report on the use of hollow cathode plasma (HCP) for low-temperature plasma-assisted ALD of crystalline AlN, GaN and $Al_xGa_{1-x}N$ thin films with low impurity concentrations. To the best of our knowledge, this is the first study reporting on the integration of HCP and ALD, as well as the first low-temperature self-limiting growth of crystalline $Al_xGa_{1-x}N$ thin films.

RESEARCH GROUPS

Supramolecular Chemistry and Chemical Nanotechnology

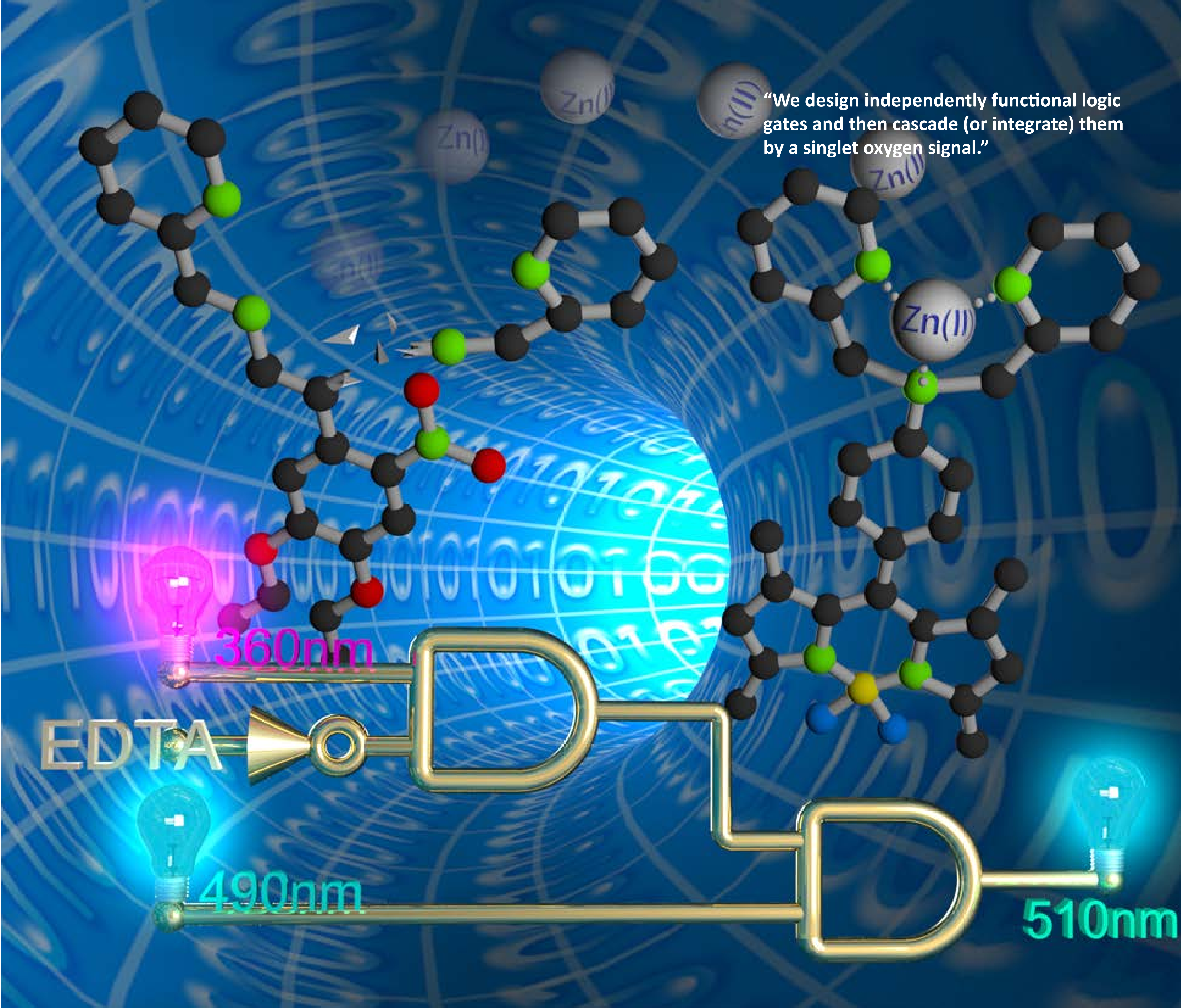
Rational design of molecular or supramolecular structures with emergent functionalities is the primary target of our research efforts. To that end, we are trying to find practical applications for molecular logic gates, develop autonomous activation protocols for biologically active organic compounds and photochemically modulate various chemical and physical properties of molecular systems.

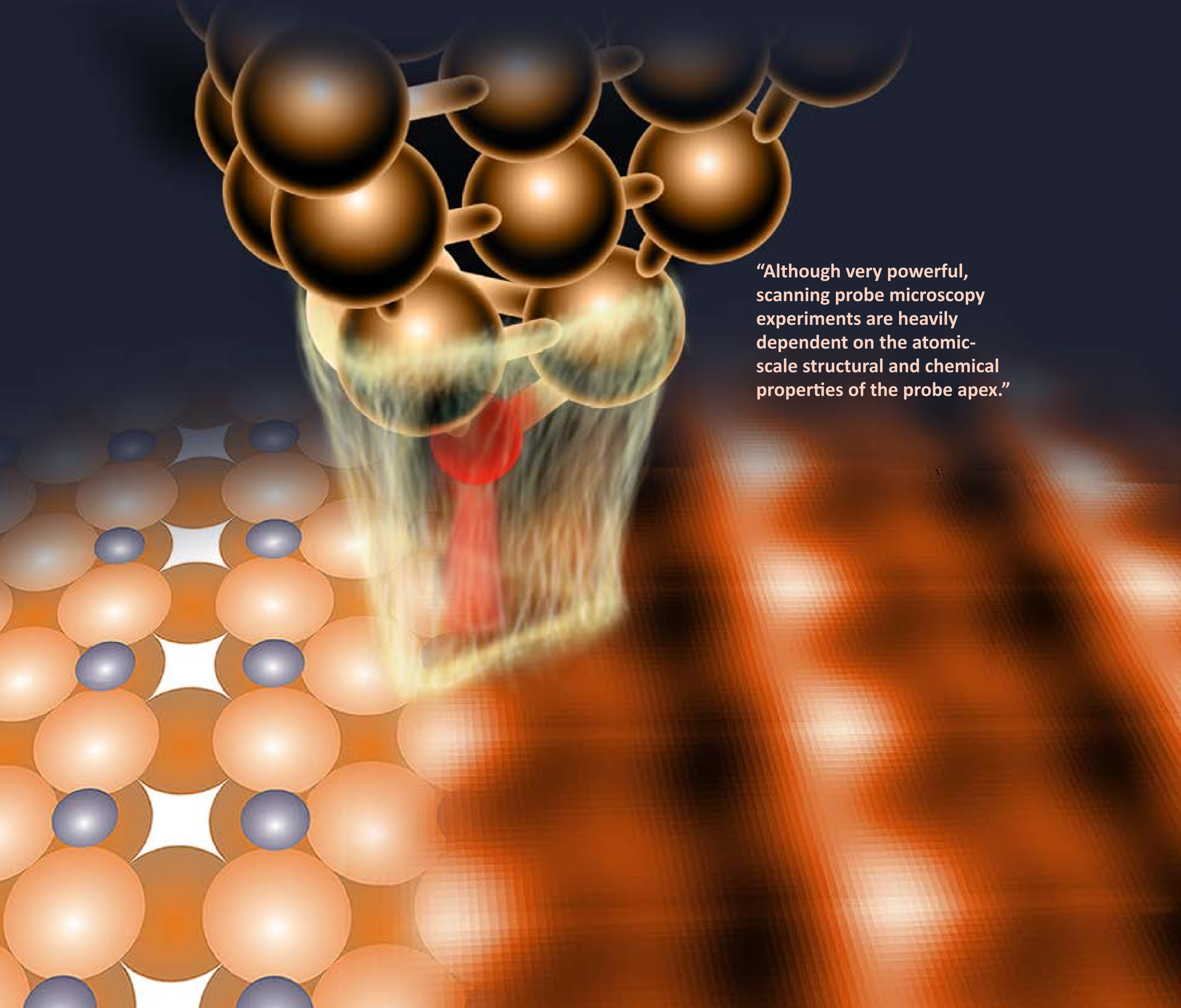
Our research group has contributed to the development of molecular logic gates over the years. We, among a few others are convinced that the first unequivocal application will present itself in the nanomedicine field. One particular field of inquiry which could benefit from such fusion of ideas is photodynamic therapy. Photodynamic therapy (PDT) is a non-invasive method of treating malignant tumors and age-related macular degeneration, and is particularly promising in the treatment of multidrug-resistant tumors. The PDT strategy is based on the preferential localization of certain photosensitizers in tumor tissues upon systemic administration. The sensitizer is then excited with red or near infrared (NIR) light, generating singlet oxygen ($^1O_2$) and thus irreversibly damaging tumor cells. One important aspect is the tight control of the delivery of cytotoxic singlet oxygen to be produced. In an earlier design, we proposed a sensitizer which behaves as an "AND" logic gate. Singlet excited state of the sensitizer dye can take a number of different paths for de-excitation, through competing processes. Among these processes, photoinduced electron transfer (PeT), intersystem crossing, fluorescence, non-radiative de-excitation are the most prominent ones. The rates of fluorescence or non-radiative process are not affected by the modulators such as Na^+ and H^+. But, the blocking of PeT by Na^+ binding to the crown ether moiety, leaves intersystem crossing as the major path for de-excitation. This is path for singlet oxygen generation. So, increasing concentration of Na^+ ions increases the rate of singlet oxygen generation. H^+ ions influence the same rate by a different mechanism, the added acid causes a bathochromic (red) shift in the absorption spectrum. This shift moves the absorption peak to the peak emission wavelength of the LED used in the excitation. Thus, the sensitizers are more effectively excited when the medium is acidic. Although this is a proof of principle study, we already established the fact that, molecular logic holds a greater promise than previously recognized.

"A convincing application" is sorely missed in the field of molecular logic gates. In most examples, the assignment of logic gates, especially in more complex systems, is "ex post facto", resting on finding a suitable digital design that is in accordance with spectral changes. We design independently functional logic gates and then cascade (or integrate) them by a singlet oxygen signal. In addition, the resulting cascaded gates function in nanospace (inside a micelle) as a singlet oxygen generator, which also reports the rate of singlet oxygen generation. This has clear therapeutic implications within the context of photodynamic therapy.

Dr. Engin Umut Akkaya

“We design independently functional logic gates and then cascade (or integrate) them by a singlet oxygen signal.”





“Although very powerful, scanning probe microscopy experiments are heavily dependent on the atomic-scale structural and chemical properties of the probe apex.”

Surface Science on the Nanoscale

Various phenomena of scientific and technological importance such as friction, adhesion, corrosion, and heterogeneous catalysis take place at material surfaces. A full understanding of the fundamental principles governing such processes requires detailed knowledge of the nanoscale structural, mechanical, physical, and chemical properties of the surfaces involved. In our research group, we apply and further develop scanning probe microscopy techniques to study a variety of material surfaces and associated phenomena on the nanoscale.

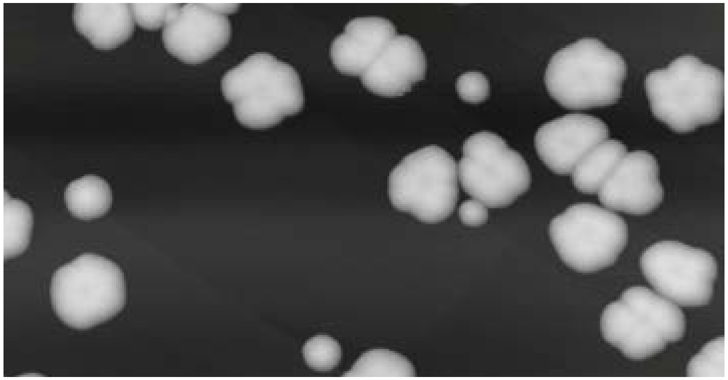
Nanotribology

Despite the fact that friction is ubiquitous in our daily lives, the fundamental physical laws that govern it are still not well understood. Motivated by the idea that an ability to predict and control friction on macro scales depends on a complete understanding of frictional processes occurring at the nanoscale, the research area of nanotribology (the science of friction, wear and lubrication on the nanoscale) has been formed.

In our research group, we study frictional properties of metallic nanoparticles on various substrates by atomic force microscopy based nano-manipulation experiments. By studying friction as a function of interface structure and chemistry, we intend to contribute to the further development of friction laws at the nanoscale.

Probe Effects in Atomic Force Spectroscopy

Atomic-resolution force field spectroscopy is a recently developed, powerful technique used to study atomic-scale physical and chemical properties of material surfaces. Despite the vast potential of the method, structural asymmetry and elasticity of the probe apex cause significant problems in correct interpretation of results. In our research group, we utilize numerical simulations to study effects associated with tip structure and elasticity in atomic-resolution force spectroscopy experiments.



Dr. Mehmet Z. Baykara

Nanoscale Materials and Nanophotonics Laboratory

In our group, researchers from a variety of fields, such as molecular biology, chemistry, physics, materials science and electronics collaborate and develop new concepts at the edge of applied sciences. Our group particularly focused on fabrication of ultra-long and aligned nanowires and their device integration, development of optical methods for chemical and biological sensing, and nanostructured surfaces with variety of functionalities.

A new nanofabrication technique

Nanowires constitute an exciting research field in nanotechnology, regarding their unprecedented characteristics compared to their bulk counterparts. Although fabrication and characterization of nanowires are quite well-established, serious problems persist in large scale integration of nanowires into functional devices, impeding their utilization in practical applications. Nanowires that we produce by iterative thermal size reduction, on the other hand, have a significant superiority, thanks to their intrinsic spatial order and exceptional length.

Chemical and Biological Sensing

We exploit interdisciplinary environment of UNAM to develop novel single molecule detection systems and artificial olfaction technologies. In microoptics sub-group we employ very high quality factor microcavities and measure the wavelength shift in the optical signal due to analyte introduction. This approach, combined with the surface modification of micro-toroids, can detect even single molecules selectively. In the photonic nose sub-group we work on a distinct opto-electronic nose concept introduced in our laboratories. This concept utilize an array of opto-fluidic hollow-core infrared fibers in order to measure infrared absorption of volatiles in a compact scheme.

Functional Nanostructured Surfaces

Nanoengineering of surfaces holds a great deal of promise for many high-tech applications including solar cells, self-cleaning windows, and chemical and biological sensors. We are producing these surfaces for variety of purposes such as to enhance the efficiency of solar cells, to produce rapid explosive sensors and to prepare reproducible SERS substrates. Also, we are collaborating with industry in order to produce surfaces that are resistive against water condensation and ice adhesion.

Dr. Mehmet Bayındır

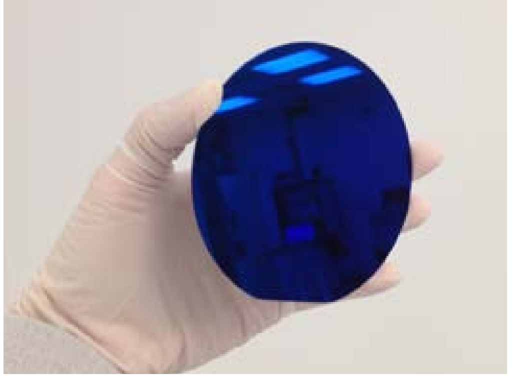
“Reinvention of fiber drawing in the age of nanotechnology: Production of indefinitely long nanostructures which pave the way for novel applications, including nanowire-based large-area flexible sensor platforms, phase change memory, nanostructure-enhanced photovoltaics, semiconductor nanophotonics, dielectric metamaterials, linear and nonlinear photonics and nanowire-enabled high-performance composites.**”**

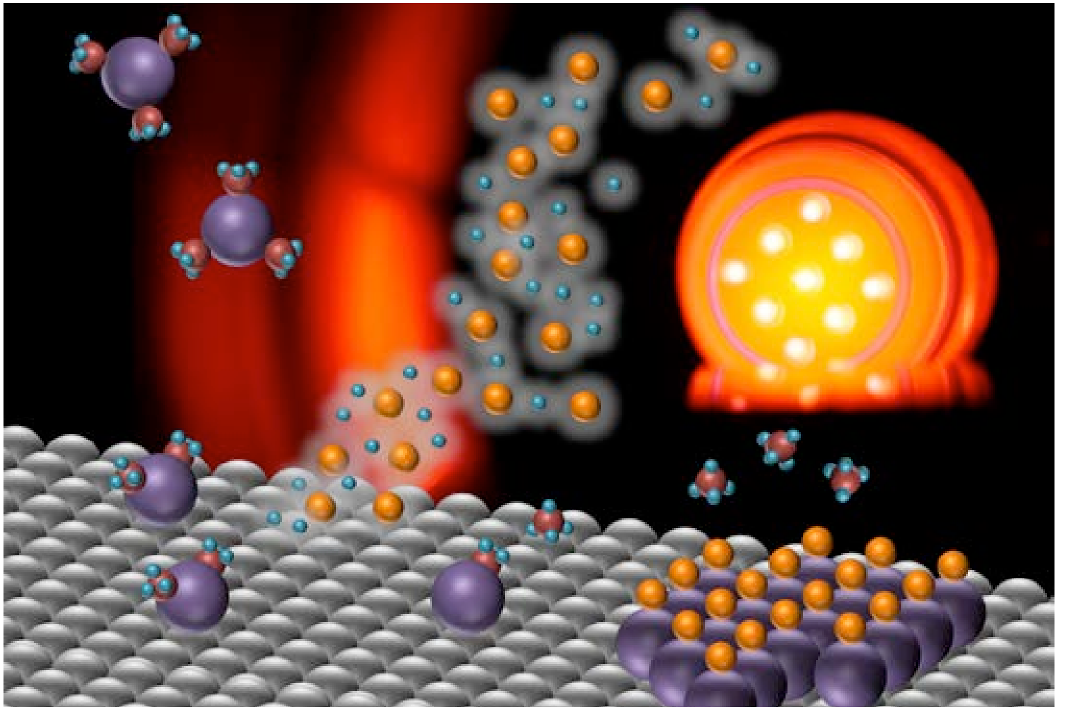
"Atomic layer deposition technique is exploited to synthesize functional III-Nitride and metal-oxide thin-film and nanostructured coatings for a variety of semiconductor device applications."

Functional Semiconductor Materials and Devices

Our research focus extends from the growth and characterization of micro/nano-scale functional compound semiconductor materials including III-Nitride and metal-oxide alloy families to the design, fabrication, and characterization of enabling devices for a variety of applications including sensor technologies, flexible and transparent electronics, renewable energy, wireless communication, and national security.

In our group, we start with the growth/synthesis of functional semiconductor materials in either thin film or nanostructured forms using mainly two materials growth techniques including chemical vapor deposition (thermal and plasma-assisted atomic layer deposition) and physical vapor deposition (DC/RF-sputtering). Growth recipes for a variety of compound semiconductor alloys including III-Nitride and metal-oxide families are being optimized through a detailed materials characterization process including structural, chemical, optical, electrical, and surface/morphological characterization tools. With the optimized recipe parameters in our hand, we target to produce a variety of devices including chemical and biological sensors, micro/nano-electromechanical actuators, electronic and opto-electronic passive and active components, photo-catalysis





coatings, organic/inorganic solar-cells, reconfigurable RF components, etc. Our main target is to contribute both to the materials and device aspect of semiconductor research:

Semiconductor materials research by investigating alternative growth techniques and combining our techniques/materials with inter-disciplinary methods/materials to produce novel micro/nano-scale functional semiconductor materials.

Semiconductor device research by using the developed materials and standard micro/nano-fabrication tools and processes, developing alternative devices for a variety of applications including but not limited to sensing, flexible and transparent electronics, renewable energy, wireless communication, and national security.

Dr. Necmi Bıyıklı

Plasmonic Sensors and Imaging

Plasmonics brings together light and metallic nanostructures to harness the benefits of electromagnetic modes of such nanostructures. Plasmonics allows control of the optical properties of surfaces and have been useful in a number of fields such as on-chip optical signal routing, biosensors, surface enhanced Raman and infrared spectroscopies. We focus on designing and realizing plasmonic surfaces for biomolecular sensing down to the single-molecule level.

From the Lab into your palm

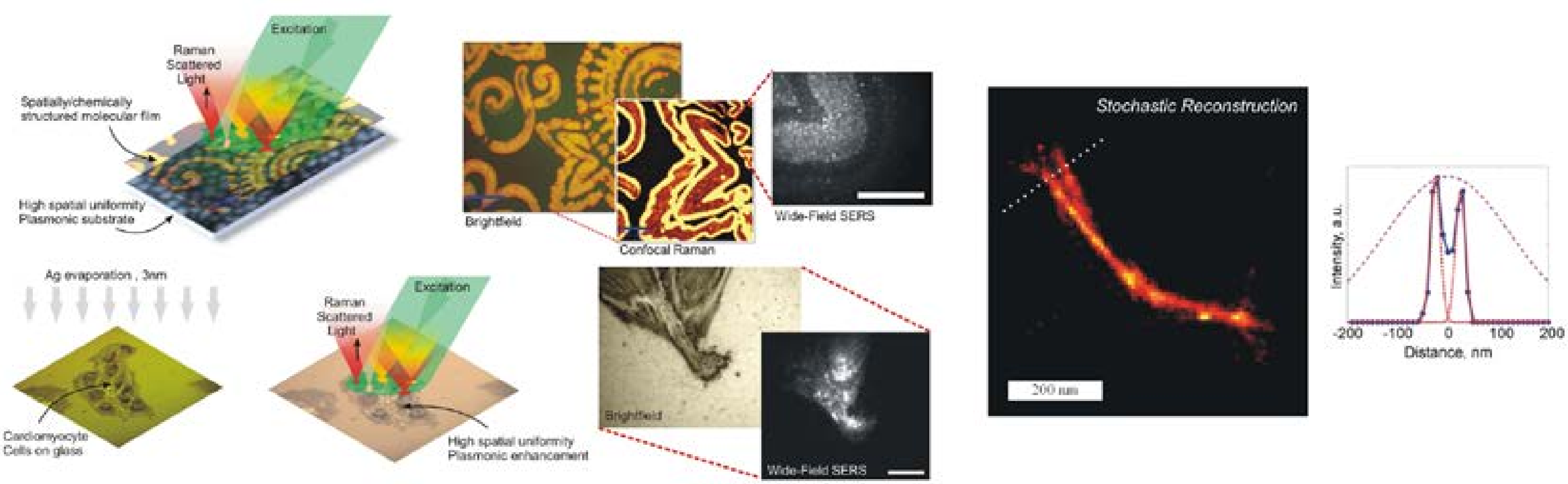
Thanks to the ever continuing development of microelectronics, we now live in an age where almost everyone carries a powerful computer, be it a mobile phone or a tablet. We use electromagnetic design and nanoscale structuring to produce surfaces and systems that enable Plasmon resonance based imaging and spectroscopy on mobile platforms. Surface Enhanced Raman Spectroscopy (SERS) is among the techniques we use to detect single molecules and their chemical fingerprints. Our surfaces allow easy production and highly repeatable SERS, that can even be detected using a cell phone camera. We demonstrate that airborne molecules can be sensed on our substrates, and potentially identified based on their Raman spectra.

Label-free imaging beyond the diffraction limit

Although optical microscopy has been particularly beneficial in biology, the so-called diffraction limit prohibited imaging of structures much smaller than the wavelength of light. This posed a limitation in the use of microscopes, which can image living things in their native environments, in imaging sub-cellular structures and activity of molecular machines. Optical microscopy is now experiencing a revival with the advent of superresolution imaging, i.e. imaging beyond the diffraction limit. We have used high density and uniformity plasmonic substrates to implement a label-free version of stochastic superresolution imaging, based on SERS. The resulting technique provided a resolution of 20 nm, and potentially allows superresolved acquisition of label-free chemical fingerprints of the imaged structures due to the chemical specificity of the Raman effect.

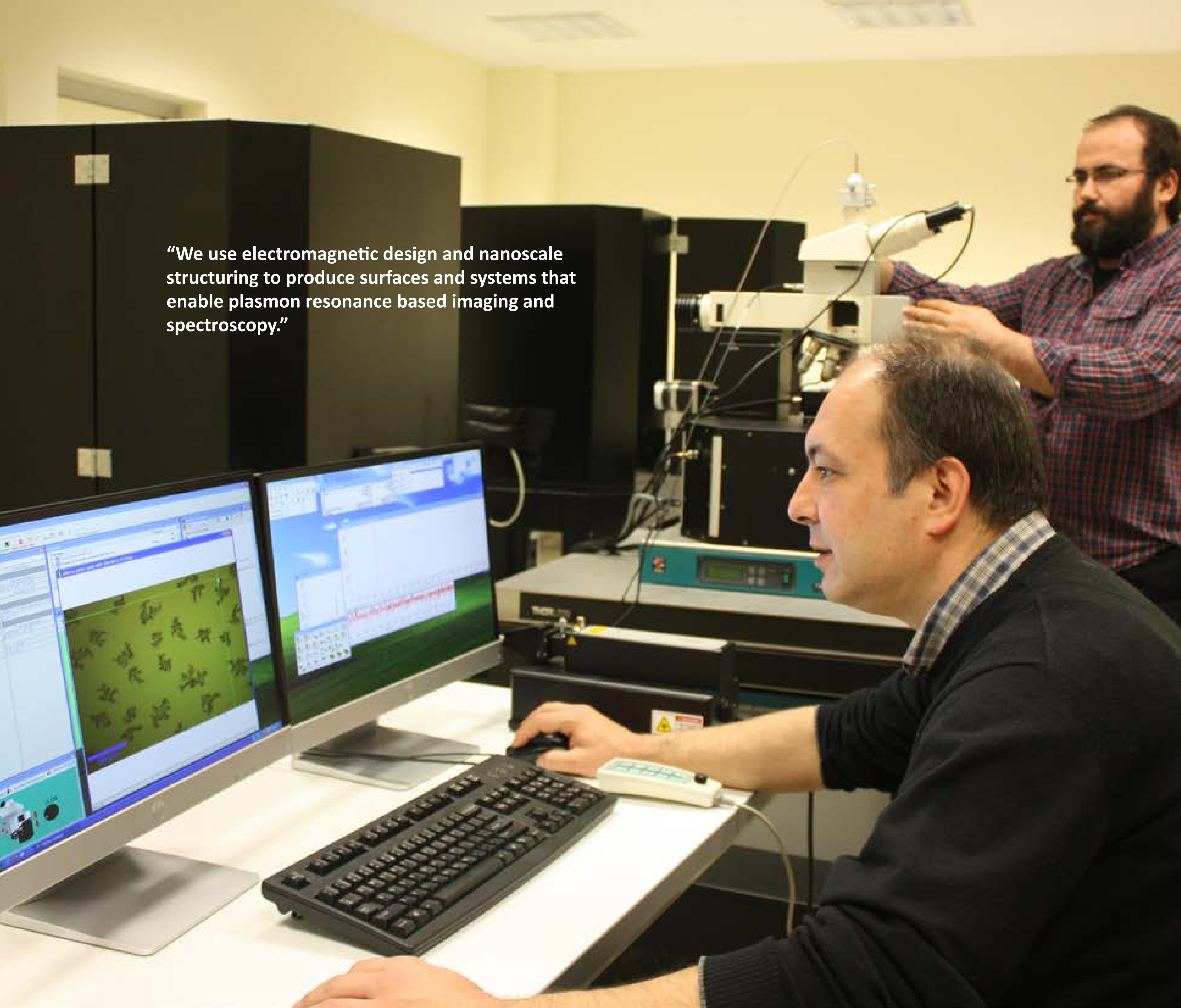
Surface Plasmon Resonance Imaging with disposable substrates

Many of the tests in healthcare rely on detection of the concentration of biomolecules in serum. Surface Plasmon resonance has been a valuable tool, used in biochemical interaction analysis and sensing, for over three decades. We use nanostructured surfaces prepared by nanoimprint lithography for array sensing using the surface plasmons. The readout system is miniaturized and integrated with a mobile phone, allowing simultaneous detection of multiple biomolecular agents using a low-cost hand-held system.



Dr. Aykutlu Dâna

“We use electromagnetic design and nanoscale structuring to produce surfaces and systems that enable plasmon resonance based imaging and spectroscopy.”



Devices & Sensors Research Group

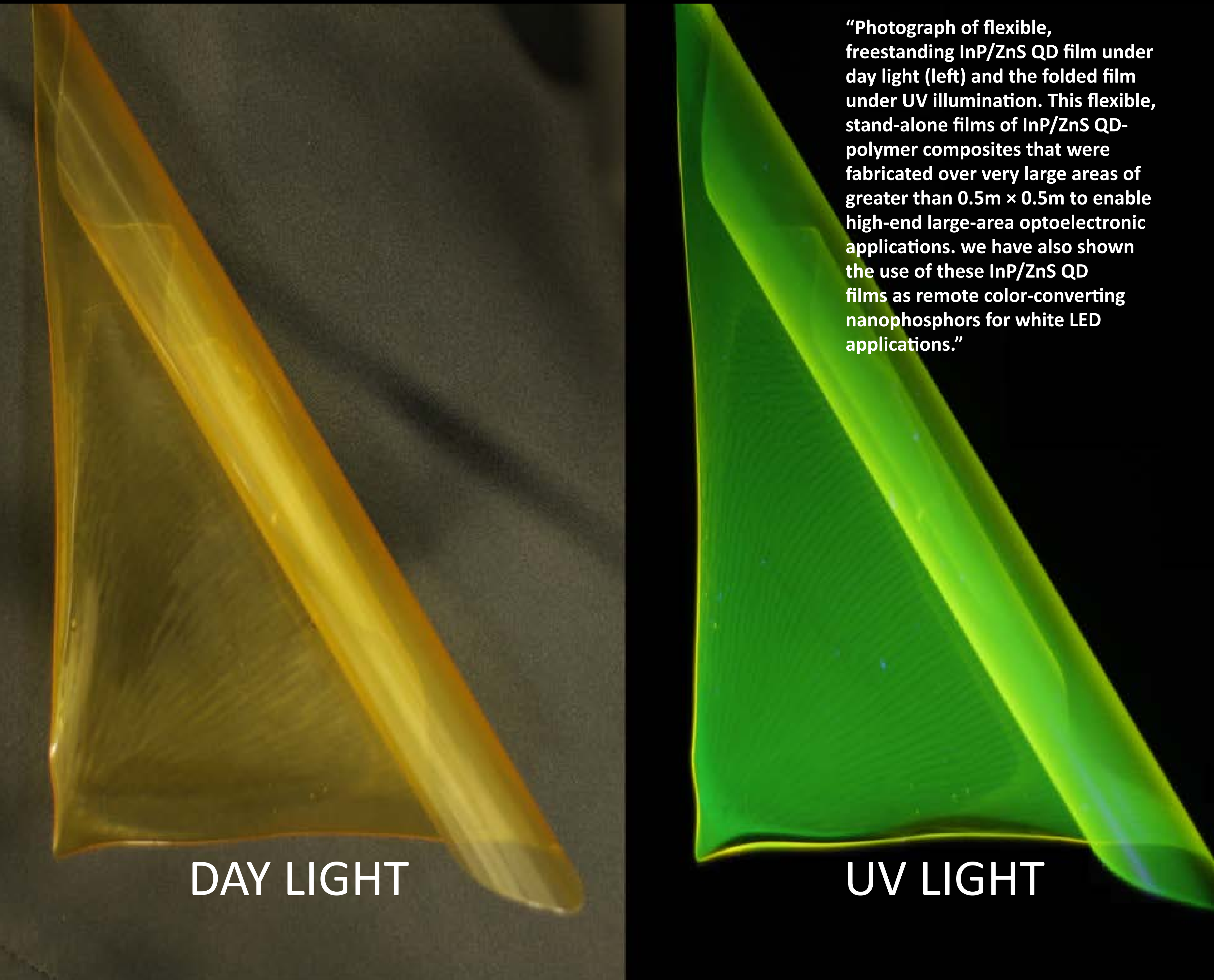
The Demir Group has been working on innovative chip-scale nanophotonic and optoelectronic platforms, embedded with nano- and microscale functional structures in hybrid architectures, high-quality high-efficiency semiconductor LED lighting devices, FRET-based light generation and harvesting, energy transfer phenomena, and nanocrystal optoelectronics, metal nanoparticles and nanowire optoelectronics, under the supervision of Professor Hilmi Volkan Demir.

Dr. Hilmi Volkan Demir

When the Devices and Sensors Research Group at Bilkent University started its research activities in 2005, the multi disciplinary research team focused on high quality white light sources based on nanocrystal hybridization with tunable photometric properties. These nanocrystals exhibit favorable electronic and optical properties with their tunable bandgap by controlling their size. Making use of multiple combinations of nanocrystals, the Group demonstrated high quality white light generation with tunable photometric properties (Nanotechnology and Nano Letters). The Group still holds the records of the best photometric performance of white LEDs (Optics Letters and Applied Physics Letters).

In parallel with these studies, the world's first nanocrystal based UV scintillator was carried out in the Demir Group, demonstrating doubled solar conversion efficiency in UV using amorphous silicon photovoltaic platform (Optics Express). Promising results have been achieved by using nanopillar structure for enhanced photovoltaic efficiency as well. Likewise, by a comparative study of nanoparticles, a substantially enhanced photocatalytic activity has been achieved for massive environmental decontamination (Applied Catalysis B: Environmental). Recently, the Group has also reported large-area (over 50 cm × 50 cm) freestanding sheets of colloidal quantum dots (Nano Letters) and polarized emission using isotropic quantum dots in plasmonic cavities (ACS Nano).

Devices and Sensors Research Group is supported by European Science Foundation (ESF), European Commission (EC), National Institutes of Health (US NIH), TÜBİTAK, Turkish Academy of Science (TÜBA) and some important private and public industrial institutions.



"Photograph of flexible, freestanding InP/ZnS QD film under day light (left) and the folded film under UV illumination. This flexible, stand-alone films of InP/ZnS QD-polymer composites that were fabricated over very large areas of greater than 0.5m × 0.5m to enable high-end large-area optoelectronic applications. we have also shown the use of these InP/ZnS QD films as remote color-converting nanophosphors for white LED applications."

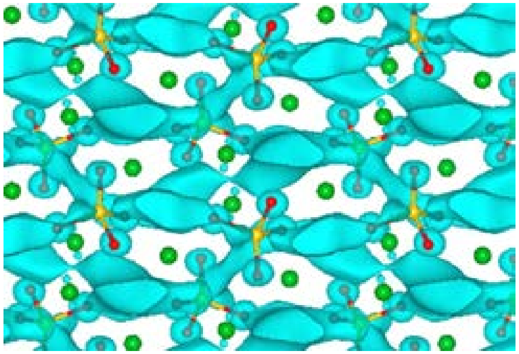
"Today, we are able to describe the behaviour of atoms and molecules in quantum world with computer simulations."

Computational Nanoscience

We are working in the multidisciplinary field of computational science, which intersects physics, chemistry, and materials science. We focus on the application of state-of-the-art modeling and simulation tools to understand, predict, and design novel materials systems to address critical challenges of global importance. We are particularly interested in investigating 2D materials at the nanoscale, the design of solar-thermal fuel systems, and the study of green and high-performance cement.

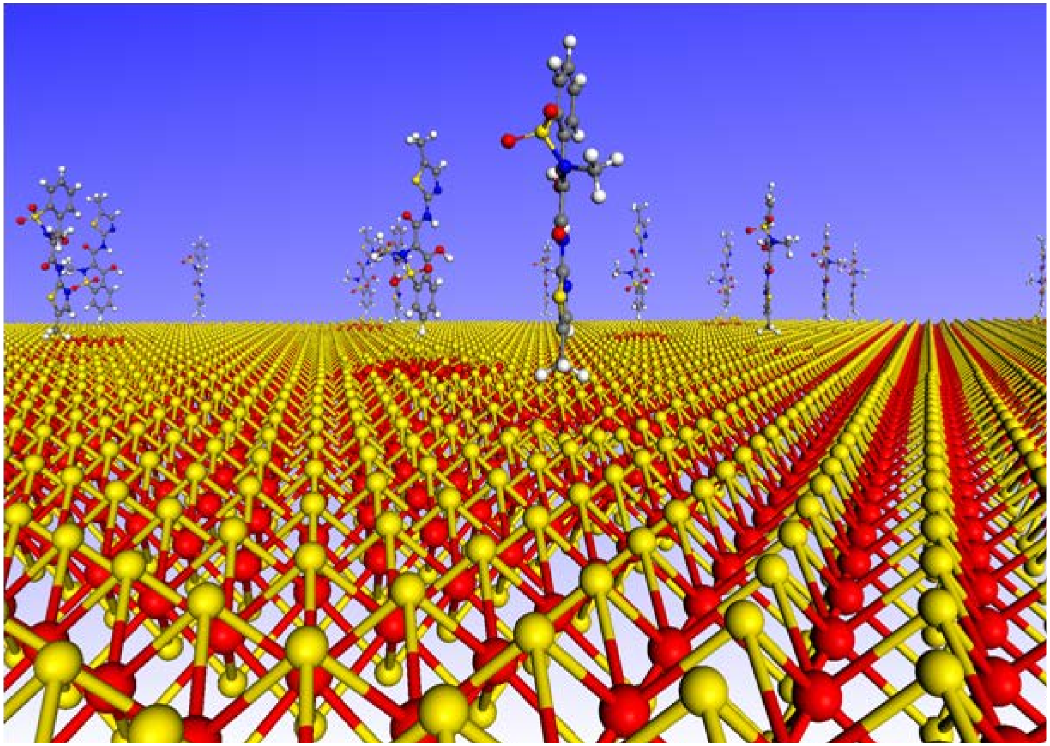
Green and High performance cement

Cement is the cause of more than 8% of global CO_2 emissions, and yet, while it is one of the most common materials in use, we have remarkably little understanding of its microscopic properties. To reduce the environmental footprint and enhance its performance a greater fundamental understanding down to the scale of its electronic properties is essential and required. We are suggesting a bottom-up approach to modify the properties at the nanoscale for new generation cement.



2D ultra-thin systems

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



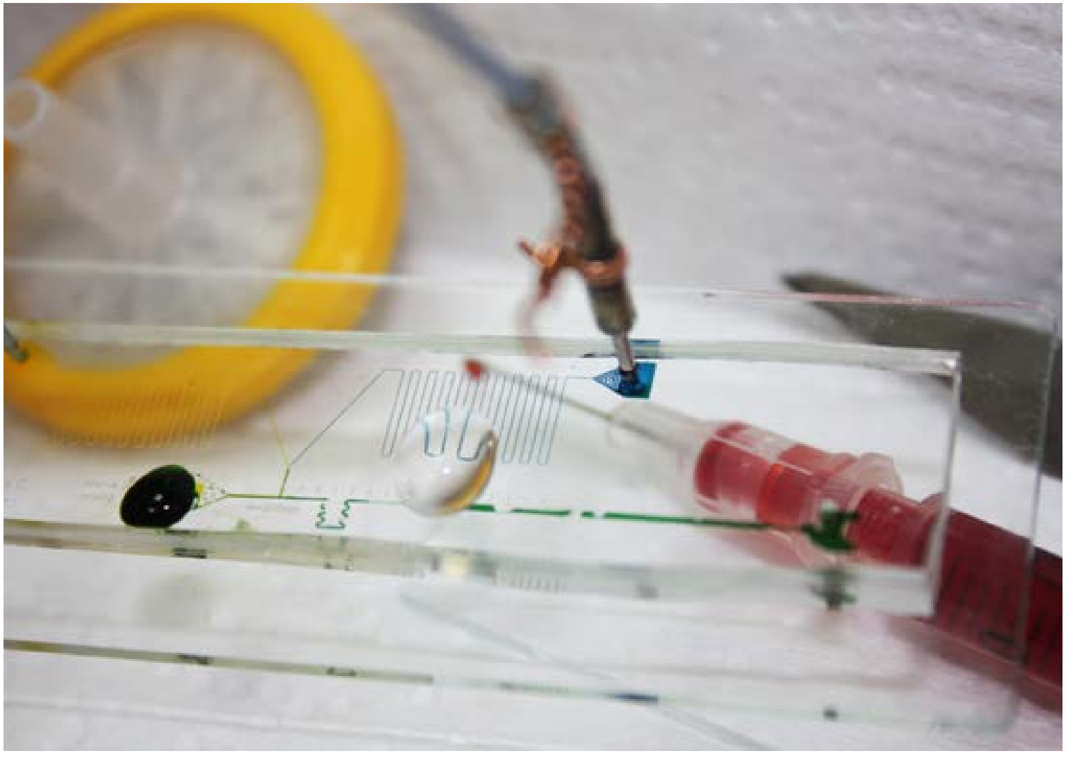
Solar-Thermal Fuels

Efficient utilization of the sun as a renewable and clean energy source is one of the greatest goals of this century. An alternative and new strategy is to store the solar energy directly in the chemical bonds of photoconvertible molecular systems. We suggest different approaches and ideas to design materials for solar fuel applications and investigate methods to increase the energy storage capacity and life-time of the product.

Dr. Engin Durgun

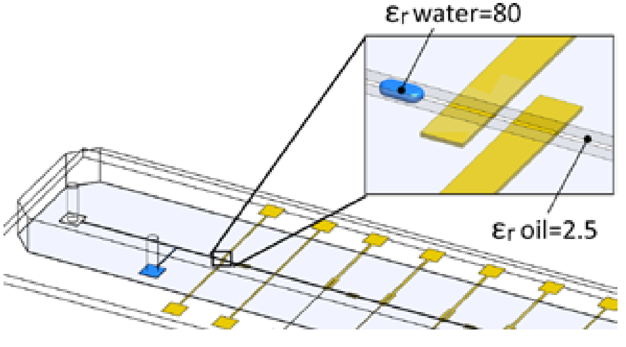
Micro/Nanofluidics and Lab on a Chip Systems

We are working on developing fundamental understanding and applications of fluid flow at small scale. We are specifically interested in control of biological liquids with extreme precision. Exquisite control of nanoliter size fluid packages enables high throughput studies using minute amounts of samples. Such systems address a broad range of applications. We explore applications in single cell studies.



Microdroplet based systems

Recently, we have developed microdroplet based platforms that utilize two phase flow. We are combining these systems with portable electrical sensors for real-world applications. Using these systems we can study viability of biological samples in nanoliter sized microdroplets under different buffer conditions. Integration of these systems with low-cost electronics opens the avenue for rapid diagnostic and screening applications. The system we are developing is especially powerful in assays requiring high througput. The system is reprogrammable, i.e. the size and the speed of the droplets generated can be fine tuned in pico/nanoliter range. The system can be automated to measure the viability of cells in each and every droplet. We are interested in applying this system to study antibiotic resistance of single cells and cell colonies.

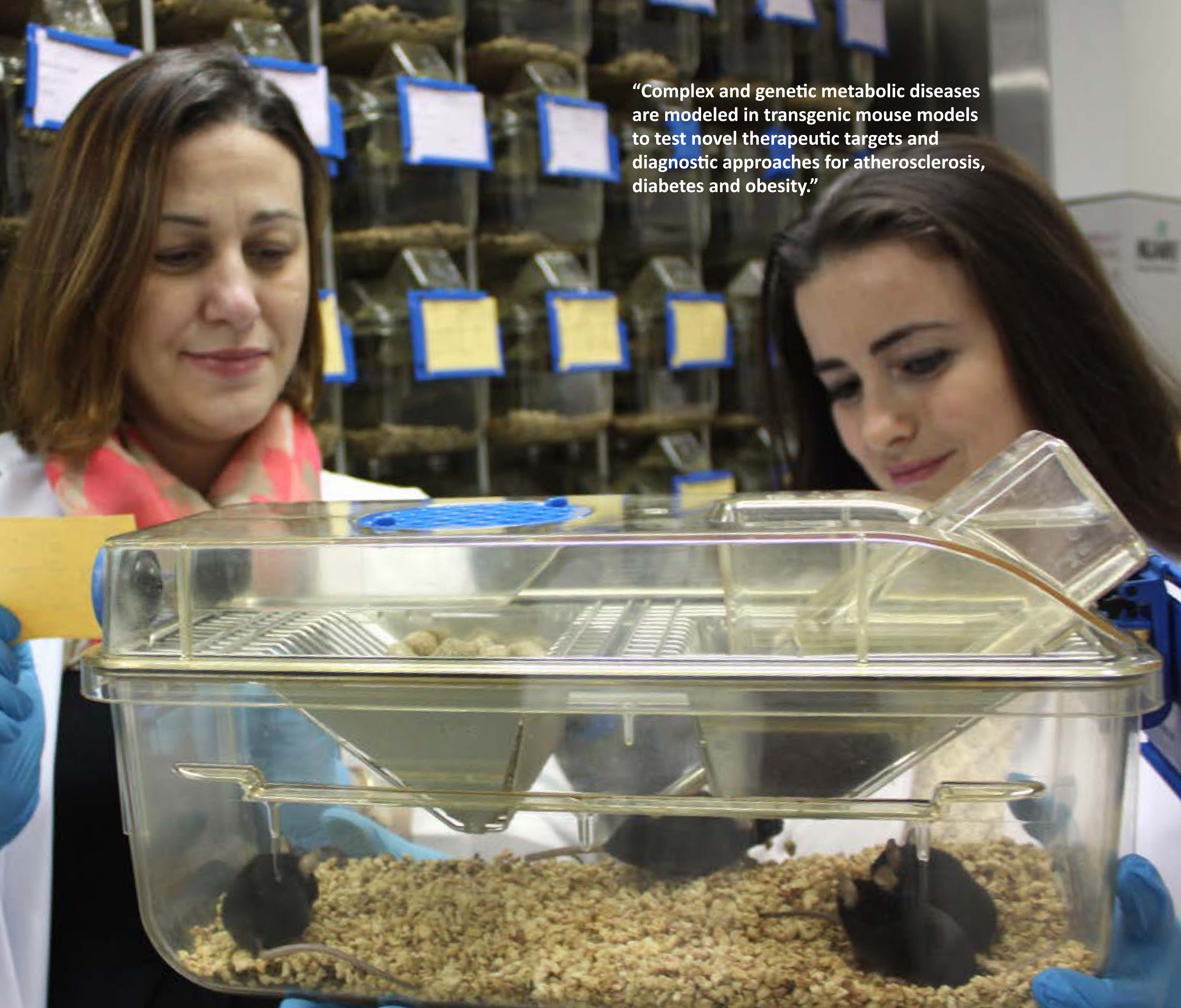


Point-of-care diagnostics

We are also working on point-of-care diagnostic devices. Point-of-care devices are becoming more popular due to raising interest in personal health. Development of these systems requires a deep understanding of fundamental fluid flow mechanisms and enabling sensing technologies. Currently, we are working on a mobile platform for detection of cardiac troponin-I, which is a biomarker for rapid diagnosis of myocardial infarction.

Dr. Çağlar Elbüken

“The microdroplet based fluidic systems combined with electrical detection mechanisms enable high throughput, automated study of biological and chemical processes.”


"Complex and genetic metabolic diseases are modeled in transgenic mouse models to test novel therapeutic targets and diagnostic approaches for atherosclerosis, diabetes and obesity."

Novel Therapeutics & 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.

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.

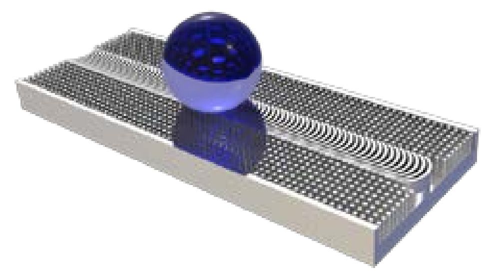
Dr. Ebru Erbay

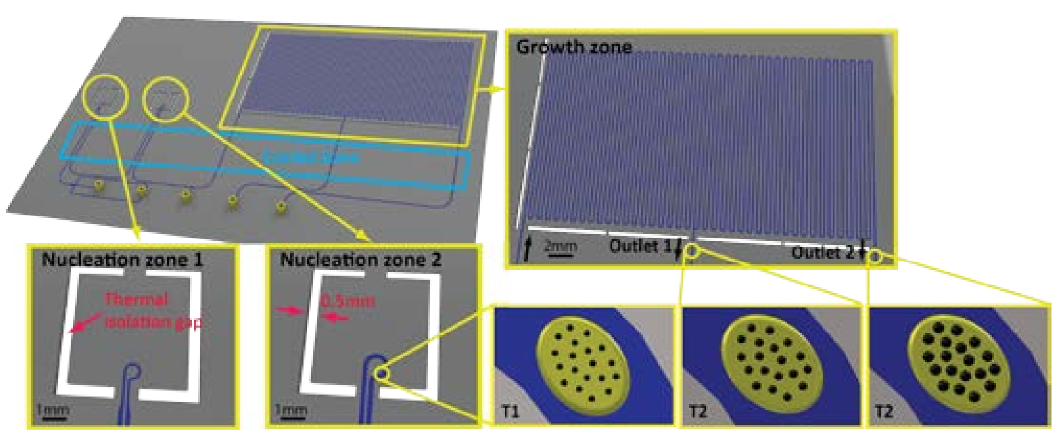
Micro and Nano Integrated Fluidics (MiNI) Lab

MiNI Lab 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.

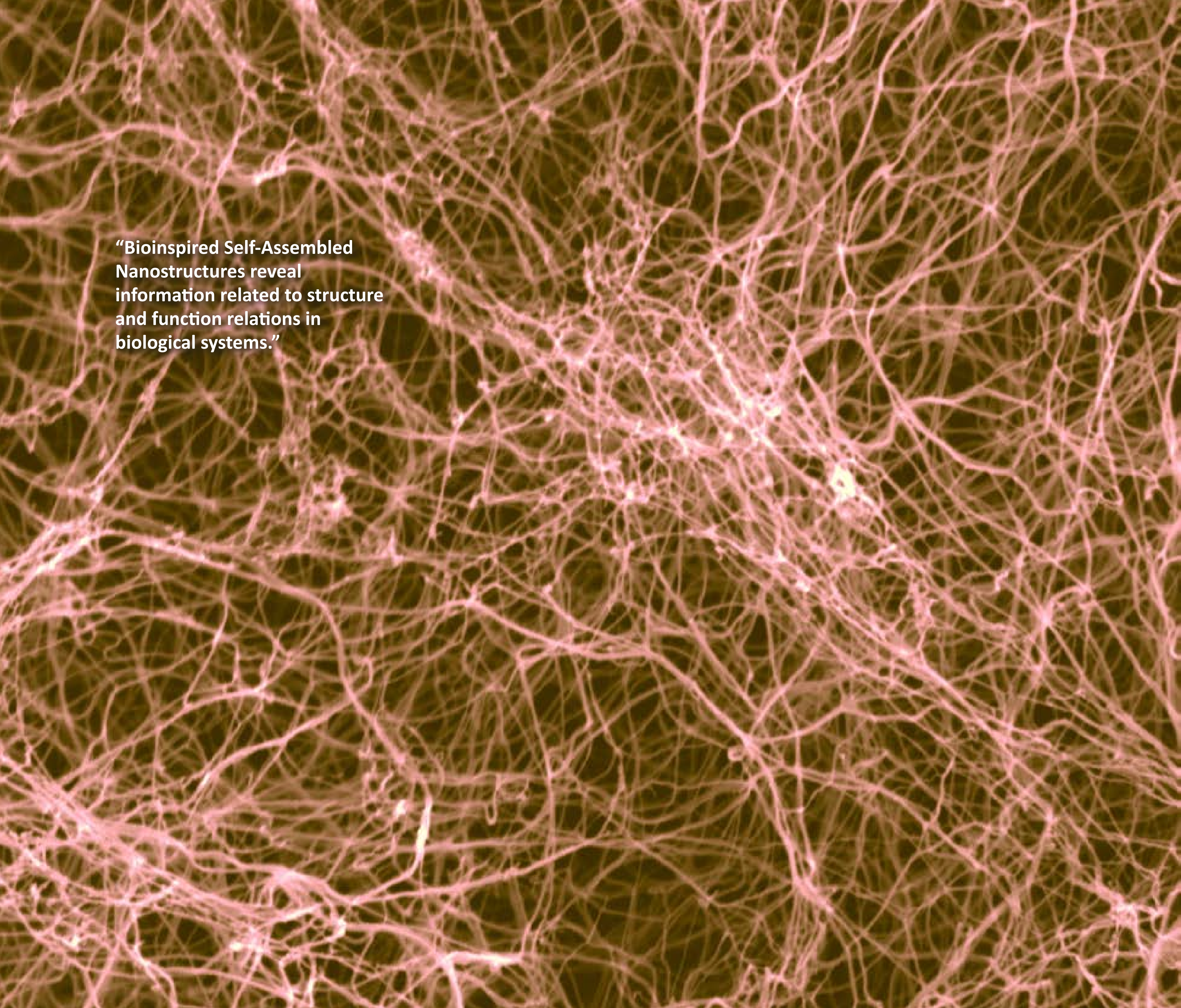
In the MiNI Lab we plan to develop microfluidic networks for assembling nanomaterials on substrates to create smart surfaces. Nanomaterials can be delivered to specific locations by using a combination of microfluidic channels and textured surfaces. Once they are delivered to the location, the solvent 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.





Dr. Yegân Erdem

“MiNI Lab brings microfluidic solutions to nanomaterial technology.”



"Bioinspired Self-Assembled Nanostructures reveal information related to structure and function relations in biological systems."

Biomimetic Materials Laboratory

Research at Biomimetic Materials Laboratory (BML) is based on discoveries at the interface of chemistry, biology, and materials science. We study concepts of making smart materials, which mimic the structure and function of the biological materials through programmed self-assembly of small molecules. Development of self-assembled biomimetic materials and integration of these materials to the material science applications are appealing motivation of our studies. BML group incorporates diverse scientific disciplines and collaborates with different research groups.

Self-assembly is an important technique for materials design using non-covalent interactions including hydrogen bonds, hydrophobic, electrostatic, metal-ligand, π-π and van der Waals interactions. Various self-organized supramolecular nanostructures have been produced by using these non-covalent interactions. Diverse functional groups can also be incorporated into nanostructures, for example bioactive peptide sequences and metal chelating groups as well as hydrophobic motifs that include alkyl chains, steroid rings, and aromatic systems. The potential impact of these nanostructures on biomaterials, regenerative medicine, drug delivery, bio-imaging, biophysics, biomechanics, catalytic systems and photovoltaics is being studied.

Understanding of the supramolecular architecture of peptides, proteins and other cellular components is of vital importance in life sciences research and may facilitate better understanding of structure-function relations in biological systems. The novel systems exist in nature inspires us to design biocompatible, biodegradable and biofunctional systems such as glycosaminoglycan mimicking peptide nanofibers, hybrid peptide/polymer networks, multivalent glyco-nanostructures, zero and one-dimensional self-assembled nanostructures for catalysis, metal incorporation and bioimaging, mechanically stable amyloid inspired hydrogels, mussel adhesion inspired biointerfaces, gene and drug delivery agents; liposomes, peptide nanonetworks, oligo-peptide ensembles that are developed in our laboratory.

Dr. Mustafa Özgür Güler

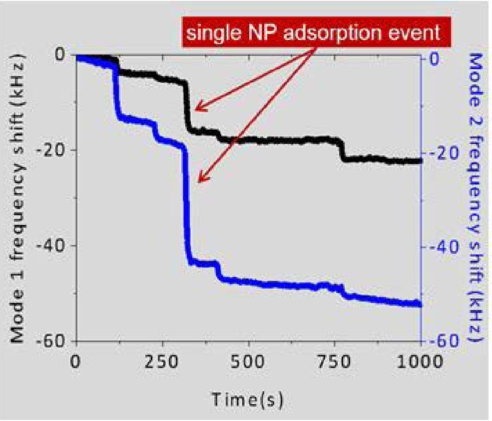
Nanoelectromechanical Systems (NEMS)

We are engineering ultra-small mechanical machines to develop novel sensor technologies for biological and environmental problems. Thanks to their miniscule size, these sensors are extremely sensitive to physical changes. We are developing NEMS-based mass spectrometry systems that enables chemical analysis at the single molecule level. These small systems have transformative potential for future applications in mobile, biochemical screening.

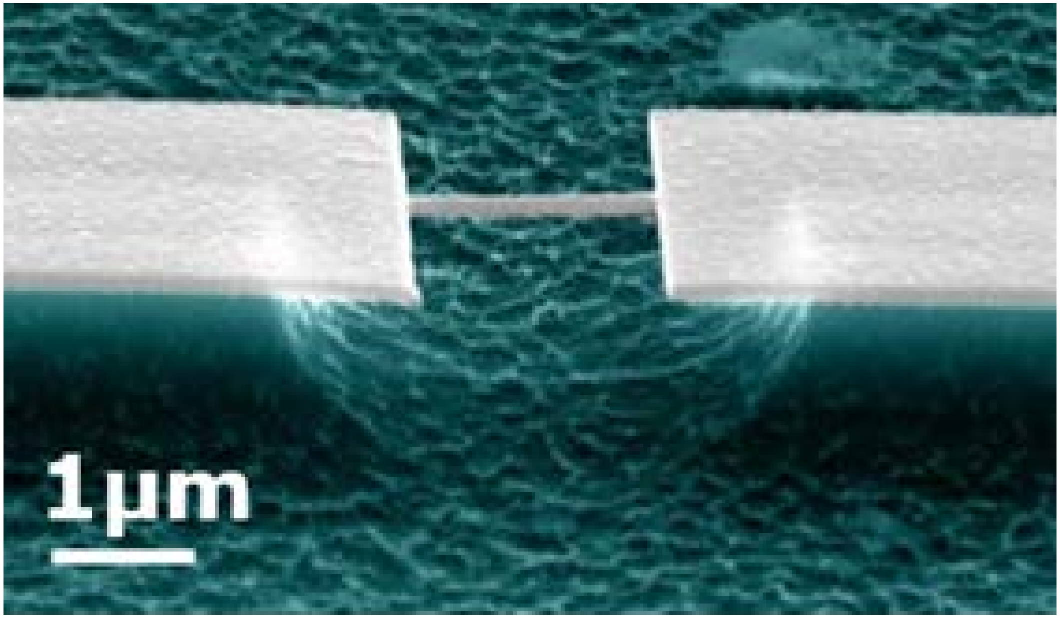
Nanoelectromechanical Systems (NEMS) are electronically controllable, submicron-scale mechanical devices used in fundamental studies as well as application oriented efforts. The field has been under active development since the early-1990s . NEMS technology has recently begun to transform from the domain 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.

NEMS Mass Sensing and Mass Spectrometry

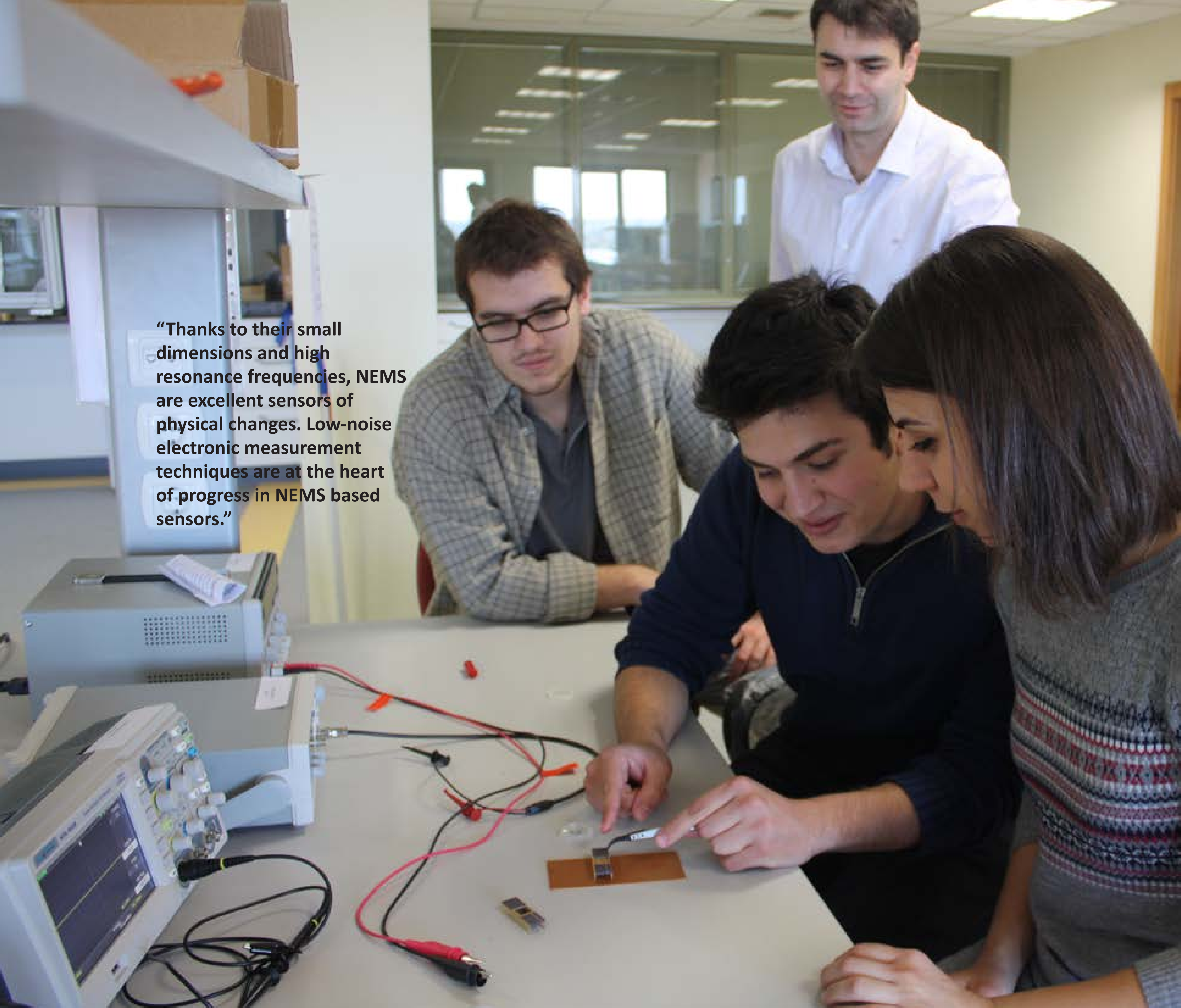
One application of NEMS technology is sensing extremely small masses. Mass sensitivity at the zeptogram (10^{-21}g) scale is possible with top-down fabricated NEMS devices. This level of sensitivity enables the mechanical weighing of single molecules which was demonstrated in 2012. The determination of molecular weight enables the identification of the molecule and opens up the possibility for chemical identification with NEMS devices.



The operation of NEMS as a mass spectrometer relies on the precise measurements of mechanical resonances. Each mechanical mode of a NEMS device has a specific resonance frequency determined by the effective stiffness and the effective mass of the particular mode. The resonance frequency is continuously monitored in experiments by a specialized electronic circuitry while sample molecules are introduced. Abrupt downward jumps in the resonance frequency are induced when an individual particle is adsorbed by the structure. From the measurement of mechanical frequency shifts, the mass of the added molecule can be determined.



Dr. Selim Hanay


“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.”

Laser-induced Fabrication of Self-organized Nanostructures

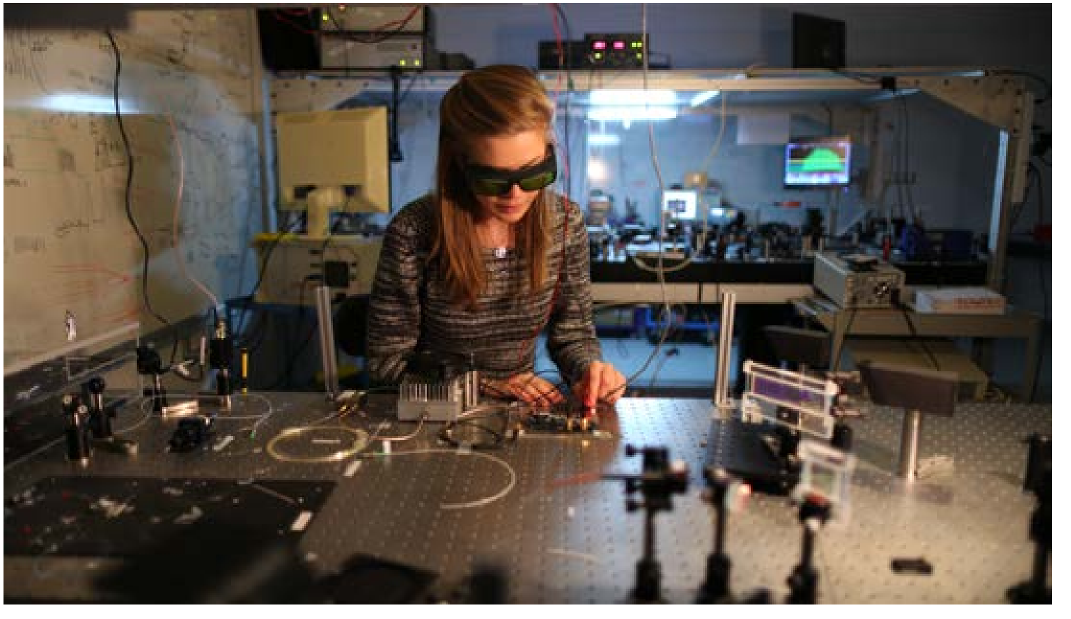
Control of matter via light has always fascinated mankind; not surprisingly, laser patterning of materials is as old as the history of the laser. We have recently demonstrated a technique, Nonlinear Laser Lithography (NLL), that allows laser-controlled self-organized formation of metal-oxide nanostructures with nanometer levels of uniformity over indefinitely large areas by simply scanning the laser beam over the surface. We now seek to vastly improve these capabilities through advanced control of the laser field and spatially selective introduction of reactive chemical species with plasma jets.

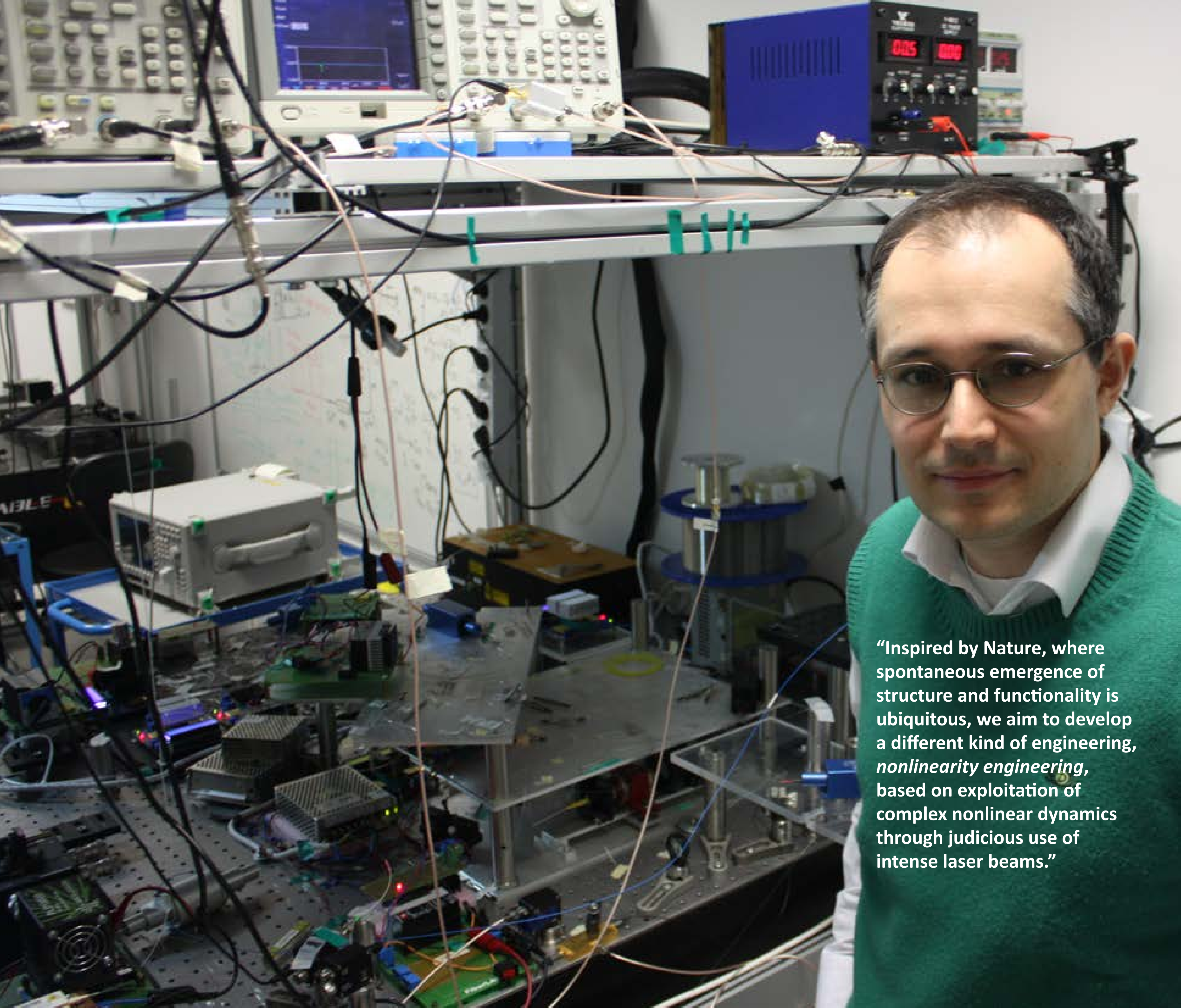
Everything in Nature is self-organized. Natural systems generate structure and functionality effortlessly from stochastic processes, often shaped by nonlinear feedback mechanisms. Our approach is inspired by such processes, which are ubiquitous in Nature, but rare in man-made technology. Intense coherent electromagnetic waves produced by a laser is a great tool for control. Plasma jets allow precise and spatially localized introduction of desired reactive chemical specifies onto surfaces. By combining these two powerful leverages, we are focussed on extending our control over the self-organized dynamics to fabricate a plethora of 2D patterns of a wide range of material compositions, eventually assembled layer by layer into the third dimension.

Dr. F. Ömer İlday

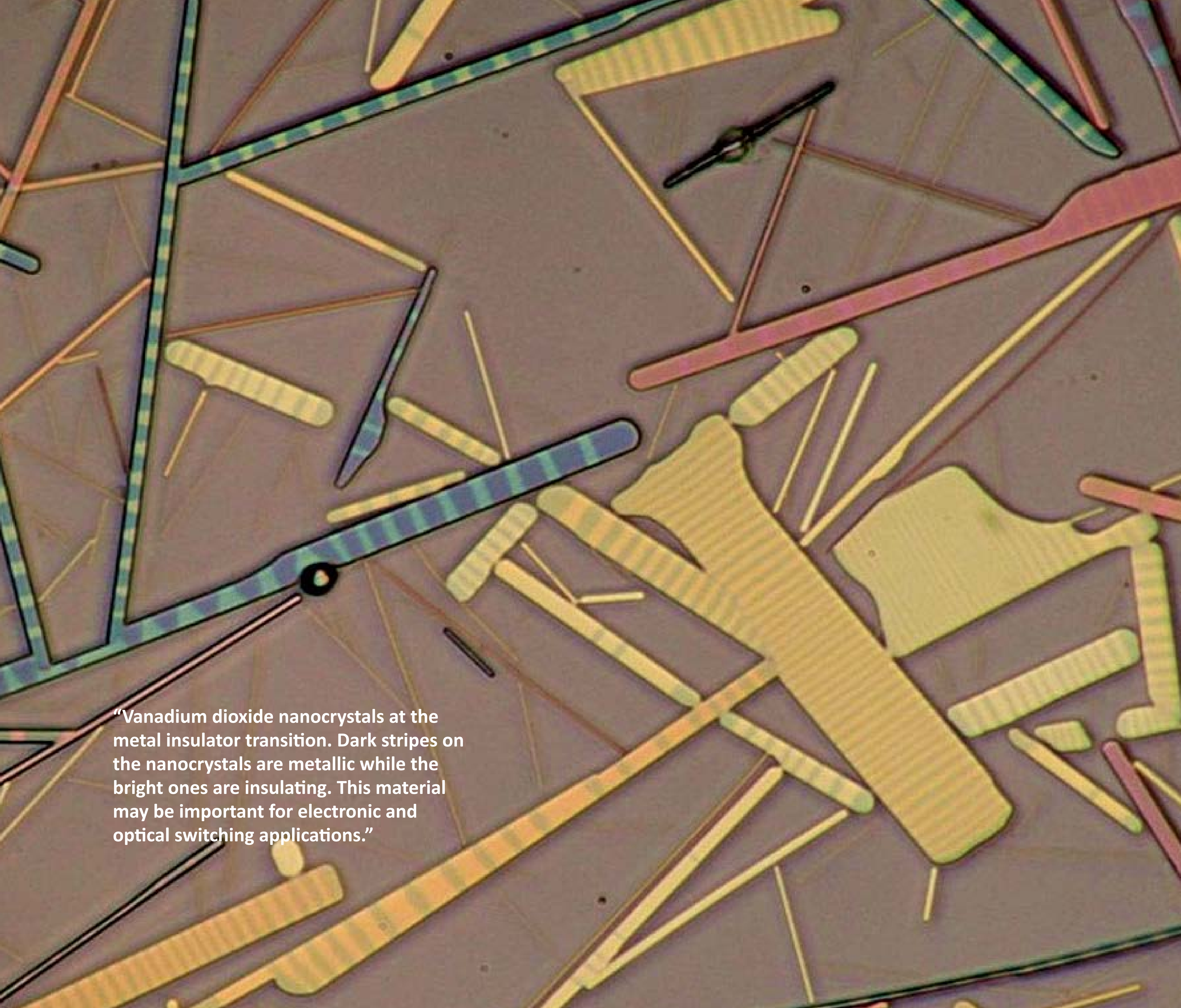
The primary motivation for this work stems from a desire to understand how to effectively control self-organized processes involved in laser-material interactions. The broader context is that, we believe, by exploiting nonlinear mechanisms inherently present in many physical systems, we can achieve amazing technological functionalities, which are difficult or impossible to achieve in strictly linear systems. Besides this fundamental motivation, various practical applications can be envisioned, building on the capability of NLL to work on flexible, non-flat, and even rough surfaces, consequently, technical materials. This is an effort funded by the ERC Consolidator Grant “Nonlinear Laser Lithography”.

Other research undertaken by the Ultrafast Optics and Lasers Laboratory (UFOLAB) concerns development of novel mode-locked laser oscillators, high-power ultrafast fiber lasers and applications of the lasers we develop to biomedicine and advanced laser material processing.





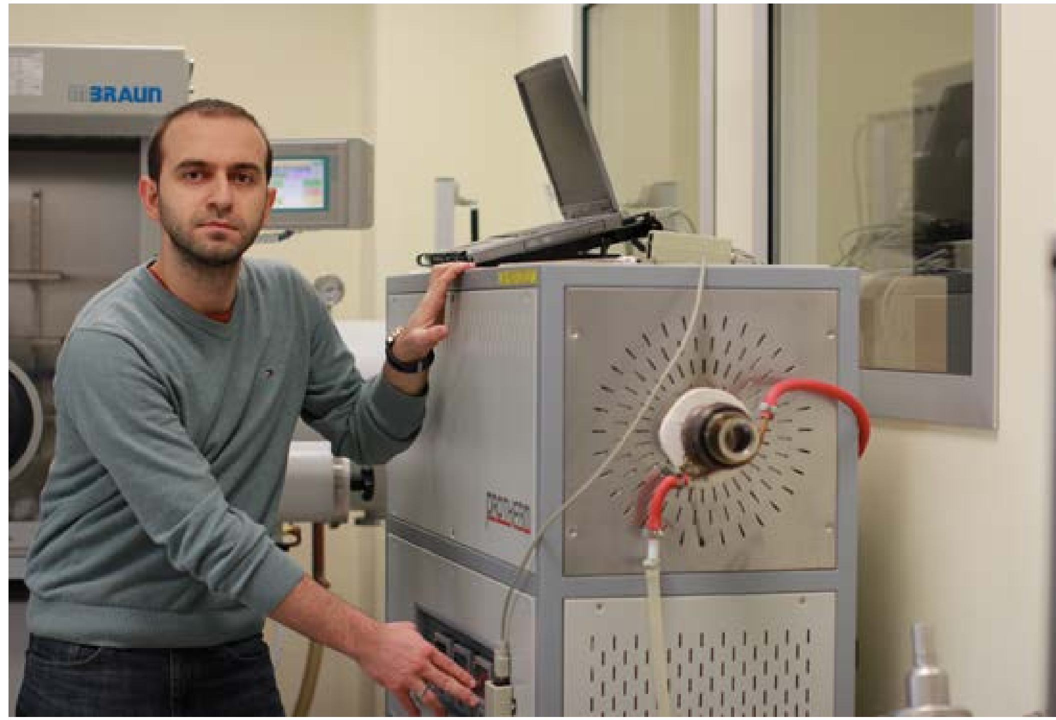
“Inspired by Nature, where spontaneous emergence of structure and functionality is ubiquitous, we aim to develop a different kind of engineering, *nonlinearity engineering*, based on exploitation of complex nonlinear dynamics through judicious use of intense laser beams.”



"Vanadium dioxide nanocrystals at the metal insulator transition. Dark stripes on the nanocrystals are metallic while the bright ones are insulating. This material may be important for electronic and optical switching applications."

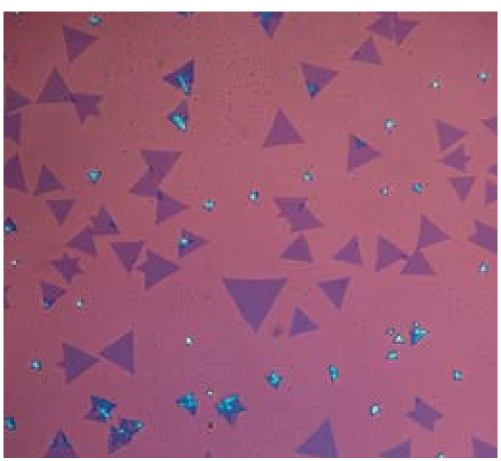
Strongly Correlated Materials

Unlike the standard materials used in the semiconductor industry, degrees of freedom exist in strongly correlated materials that could significantly impact electronic and optoelectronic technology. Our research interests lie in understanding the phenomena arising from strong electronic correlations at nano-scales and employing these phenomena for novel applications.



Studying strongly correlations at nanoscales

When the interactions between electrons with other electrons and phonons in a material are comparable to the average kinetic energy of the electrons, single electron theories fail to capture the exotic phenomena observed. Metal-insulator transition, high Tc superconductivity and giant magnetoresistance are just a few examples of the phenomena emerging from the strong correlations. Part of our research is focused on understanding the phenomena emerging from the strong correlations in materials using experimental methods and applying this practical understanding to technologically useful applications. Our research is especially focused on the metal-insulator transition of vanadium dioxide. We study nano crystals of VO_2 using optics and electronics to achieve applications in electronics and hydrogen related applications.



2D Materials

Peculiar properties of graphene have attracted waves of attention and this interest has spread to other layered materials. The reason is mainly due to possibility of applications in wide range of areas using peculiar electronic, spin, orbital and valley interactions of 2D layered material heterostructures. Strain in such materials plays an important role in material parameters such as conductivity, mobility, band gap, magnetization, valley effects etc. Using standard optical and electronic probing techniques we study the effects of strain on the properties of layered materials and purpose made heterostructure devices.

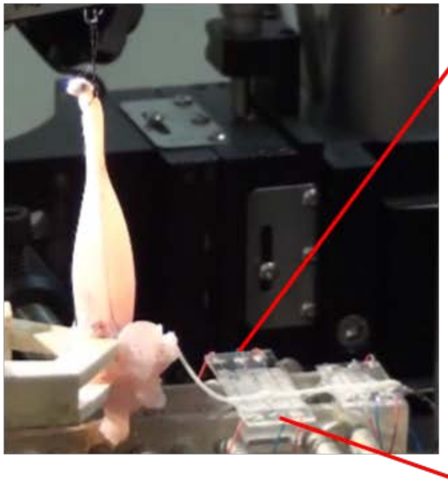
Dr. Serkan Kasırga

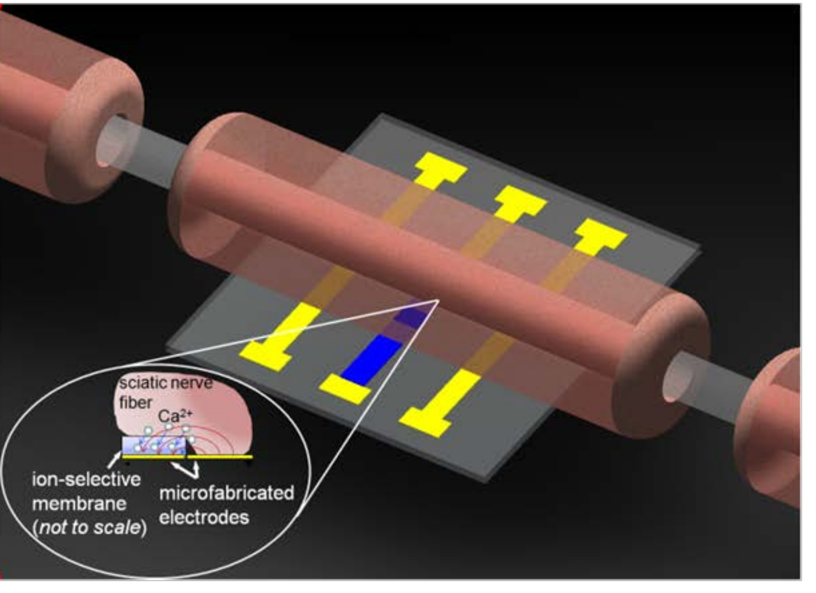
Implantable Electronics and BioMEMS Group

Our research is in the field of biomedical electronics, more specifically in implantable electronics. We study the theory and fabrication of implantable devices and sensors, which find clinical applications in real life. We made implants for early-diagnostics of orthopaedic traumas and for therapeutics of neurological disorders. We made wireless *in-vivo* (metatarsal bone) implantable sensors to monitor fracture healing. We also made implantable electrodes to activate and block the nerve (sciatic nerve) to restore the functional motor activity of patients with disabilities resulting from neurological disorders.

Today approximately one out of ten patients with a major bone fracture does not heal properly because of the inability to monitor fracture healing. Standard radiography is not capable of discriminating whether bone healing is occurring normally or aberrantly. To solve this problem, we demonstrated wireless *in-vivo* (metatarsal bone) implantable sensors to monitor mechanical strain on implanted hardware telemetrically in real time outside the body. Our sensors monitored fracture healing and provided surgeons with a powerful tool to assess fracture healing and make early diagnostics.

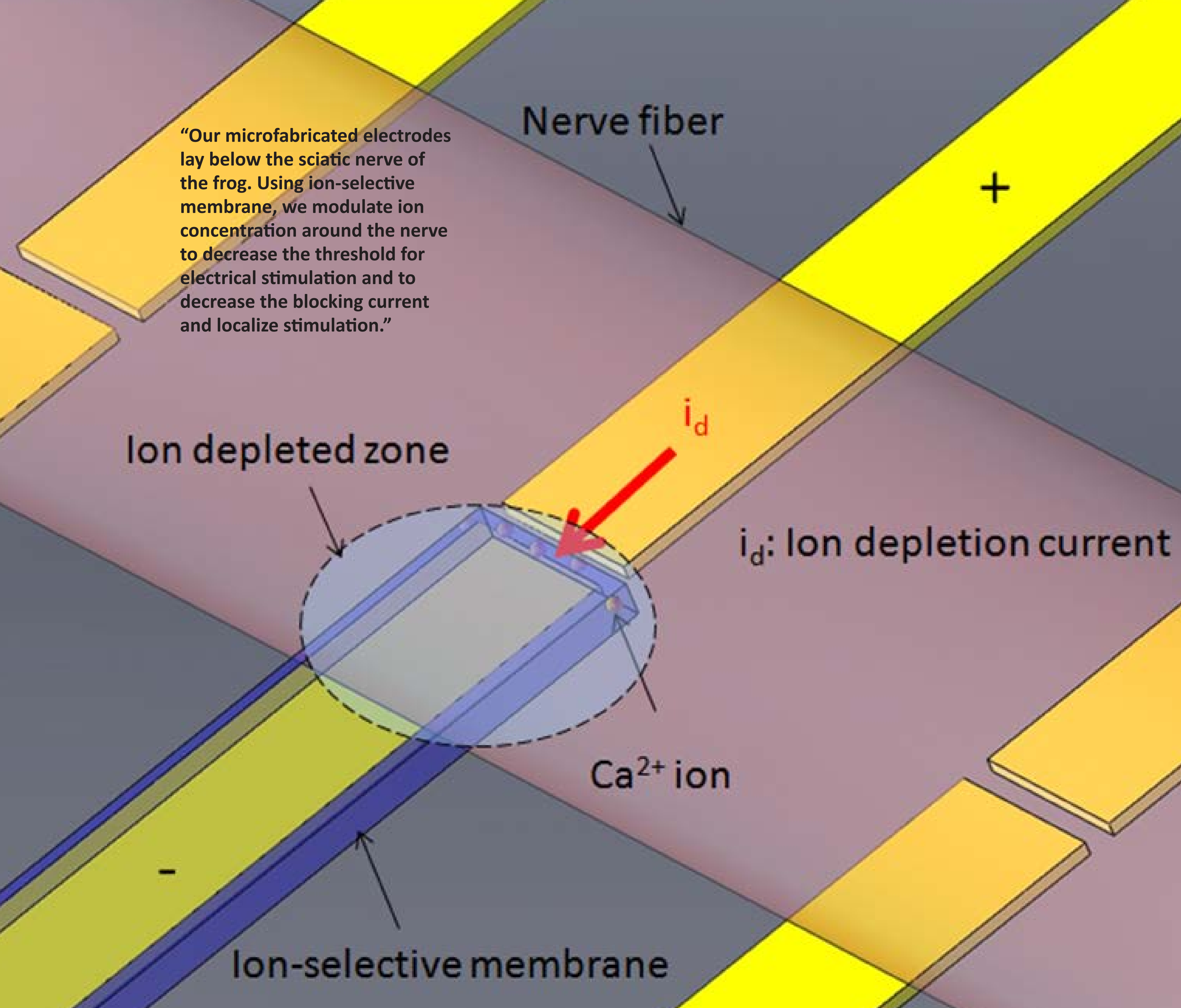
Approximately 14 million individuals in the EU population (1.7%) have forms of paresis or paralysis, and approximately 0.3% of the EU population (2.5 million people) is paralyzed due to a spinal cord injury. Conventional functional electrical stimulation (FES) aims to restore functional motor activities such as standing, ambulation, grasping and releasing. However, classical FES requires high electrical threshold value for stimulation leading to high power expenditure. Also, because of the inability of localization of the stimulation, it results in unintended or uncontrolled stimulation in neighboring nerves, causing pain. To solve these problems, we propose our novel electrochemical stimulation and blocking method to decrease the threshold for electrical stimulation and reduce power expenditure. In this project, by using our novel method, for the first time we will develop and demonstrate wireless, flexible, implantable neuroprosthetic devices. Moreover, these implants will lead to decrease the blocking current and localize stimulation.





Dr. Rohat Melik

"Our microfabricated electrodes lay below the sciatic nerve of the frog. Using ion-selective membrane, we modulate ion concentration around the nerve to decrease the threshold for electrical stimulation and to decrease the blocking current and localize stimulation."

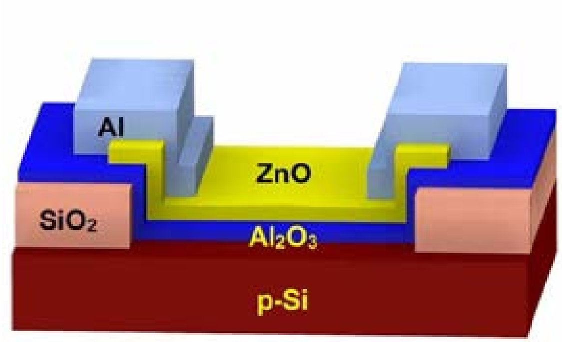


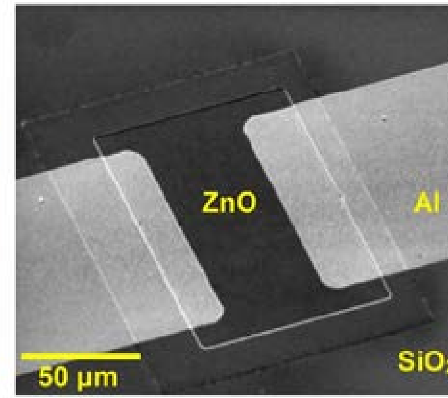
Integrated Devices and Sensors for Functional & Smart Systems

A diverse team with strong international ties: Okyay Group, composed of an international team of 25+ research students, engineers, and postdoctoral researchers, is globally recognized for groundbreaking work on semiconductor devices and sensors. Okyay Group is collaborating with national and international research groups, by joint projects and scientific publications as well as student exchange.

Cutting edge research

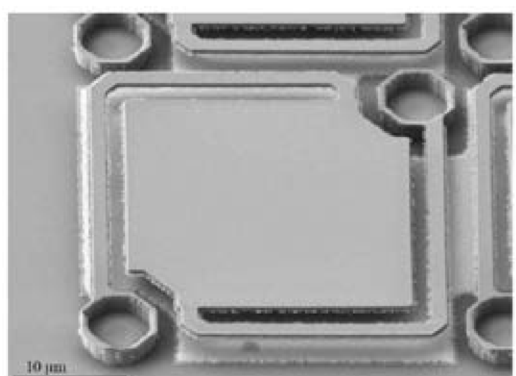
Research topics include the development and demonstration of innovative nanophotonic devices based on smart materials, nanocrystal, metal nanoparticle and nanowire embedded nanodevices, novel memory devices, high-performance RF and optoelectronic sensors, atomic layer deposited III-nitride layers and optoelectronic devices, and nanomaterials for improved efficiency dye sensitized solar cells. To date in the Okyay Group at Bilkent, together with his research students and colleagues, resistive switching assisted active tunable photonic structures; dynamic control and electrically tunable optical properties of thin film semiconductor layers for smart systems; plasma-assisted atomic layer deposition of crystalline GaN; semiconductor-less photovoltaic devices based on plasmon-coupled hot electron collection; all-ALD memory devices with substantially enhanced performance; record-breaking high TCR (temperature coefficient of resistance) materials; and strongly enhanced dye sensitized solar cells with peptide networks have been successfully demonstrated. Dr. Okyay's PhD research focused on the development of novel ultra-compact optoelectronic switching devices for high-density optical interconnections on chip scale; his doctoral work is recognized for producing the world's first chip-scale light-to-latch concept. During his Ph.D., he also contributed to the realization of the world's smallest CMOS-compatible plasmon-coupled photodetector.





Success stories and commercialization

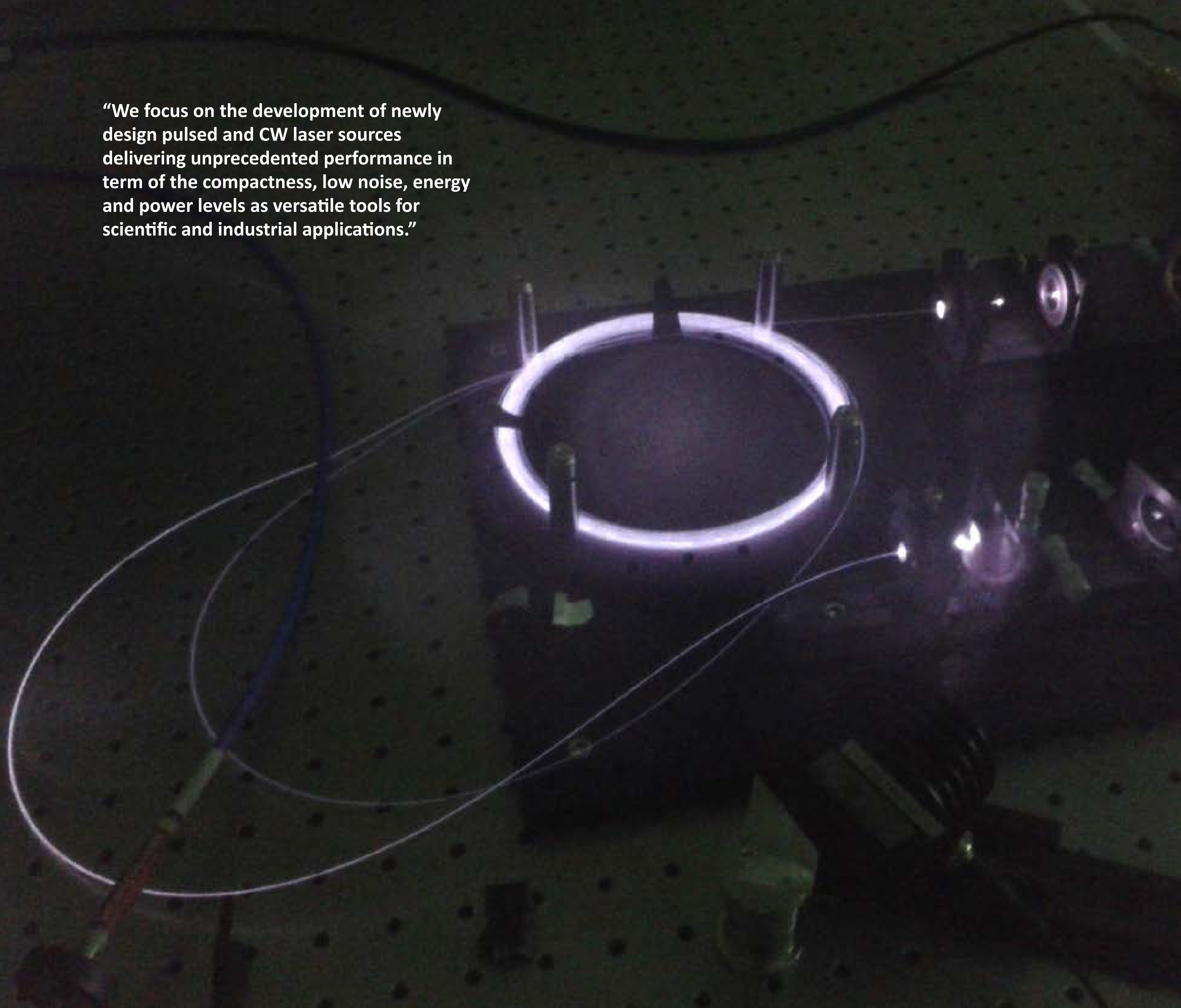
Okyay Group members' receive prestigious awards for their significant contribution to scientific community including IEEE and SPIE fellowships. Okyay Group is currently funded by 10+ international and national research projects. Various works of Okyay Group are highlighted in prestigious scientific journals such as Nature Photonics and chosen as cover in RSC Journal of Materials Chemistry. Not only we aim to push the frontier of science and technology, but also we maintain a keen eye on the commercialization of our research. A spin-off company from our group is working on next generation sensors while a recent one is manufacturing and Atomic Layer Deposition equipment.



Dr. Ali Kemal Okyay

"Not only we aim to push the frontier of science and technology, but also we maintain a keen eye on the commercialization of our research."

“We focus on the development of newly design 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.”



Laser Science & Technology

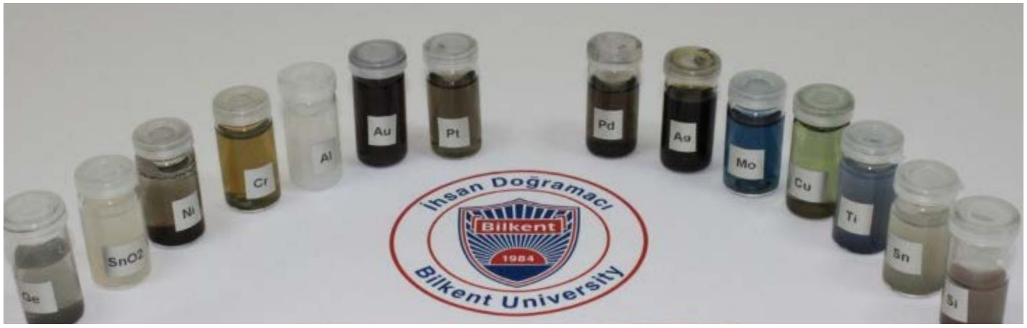
Our research activities are concentrated in the fields of laser science and technology. We design and develop powerful wide-range fiber-based laser systems. We focus on the development of newly design and original pulsed and CW laser sources delivering unprecedented performance in term of the compactness and power levels as versatile tools for scientific and industrial applications. The ongoing research activities include investigations of laser interaction with various solid and biological materials.

High-power laser lights, such as industrial, defense and health care has become extremely important for many applications. In fiber laser systems, the new generation fiber optic cables are used. Fiber laser systems, with the ease of use provided by the field, are preferred especially for high-power laser systems because of reduced heating problem, higher productivity level for increased rate of absorption of light pumped, and high-quality optical cavity laser light produced during the use and optimization of the system.

In terms of our fiber laser research, we are mainly focusing on the design and development of powerful pulsed and CW laser sources for different scientific and industrial applications. We also perform theoretical investigations on our laser systems for better understanding and control of system parameters. Those powerful laser systems can be used in different industrial areas including the defense industry.

Besides those powerful fiber laser systems, we are also working on the design and development of modulated medical lasers and medical optical fibers for different applications. We have already developed a laser system for the endovenous laser ablation operations. We are currently working on a retinal laser system.

We are working on the generation of pure and stable nanoparticles through laser ablation in 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 biological interactions.



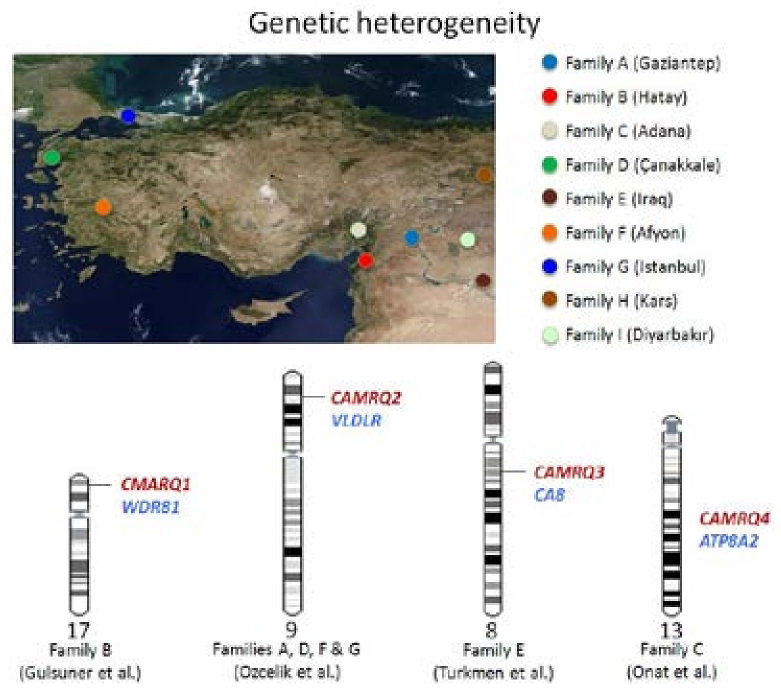
Dr. Bülend Ortaç

“Human family trees are instrumental in solving the mysteries of the genome.”

Human Genetics and Genomics

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.



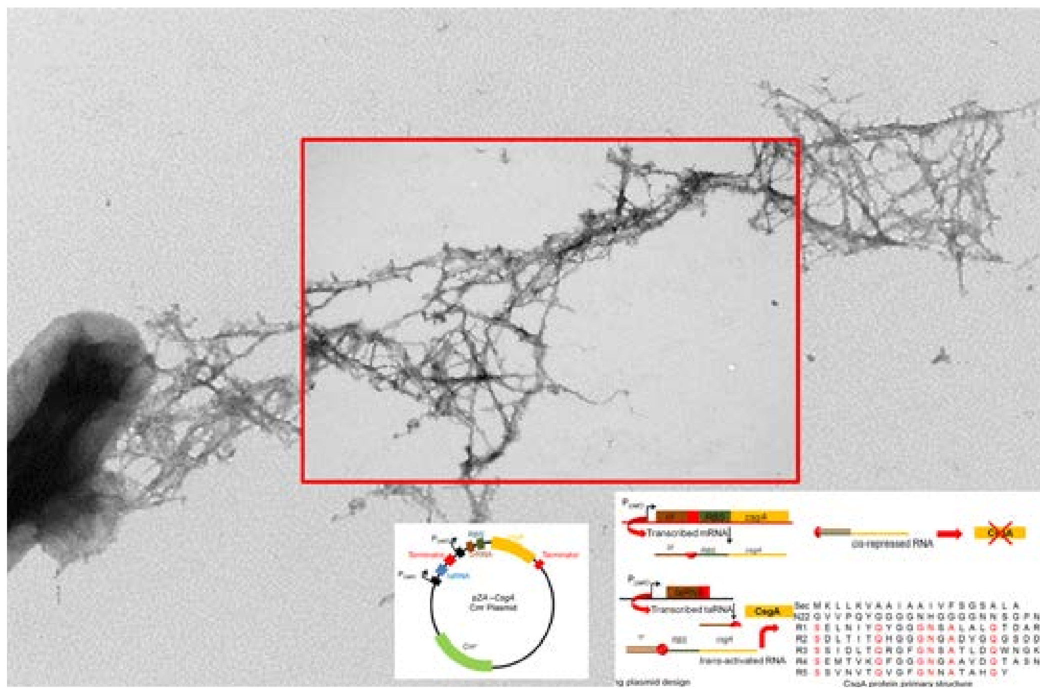
Dr. Tayfun Özçelik

Synthetic Biosystems and Bioengineering

Synthetic Biology is an emerging engineering discipline which focuses on designing and implementation genetic devices inspired by electrical engineering and computer science. We are interested in designing and implementation of genetic circuits: to build whole cell sensors, to create novel biocatalysis systems, and to produce nano/biomaterials with engineered functionality. We are also interested in designing and utilization synthetic genetic regulation systems and elements.

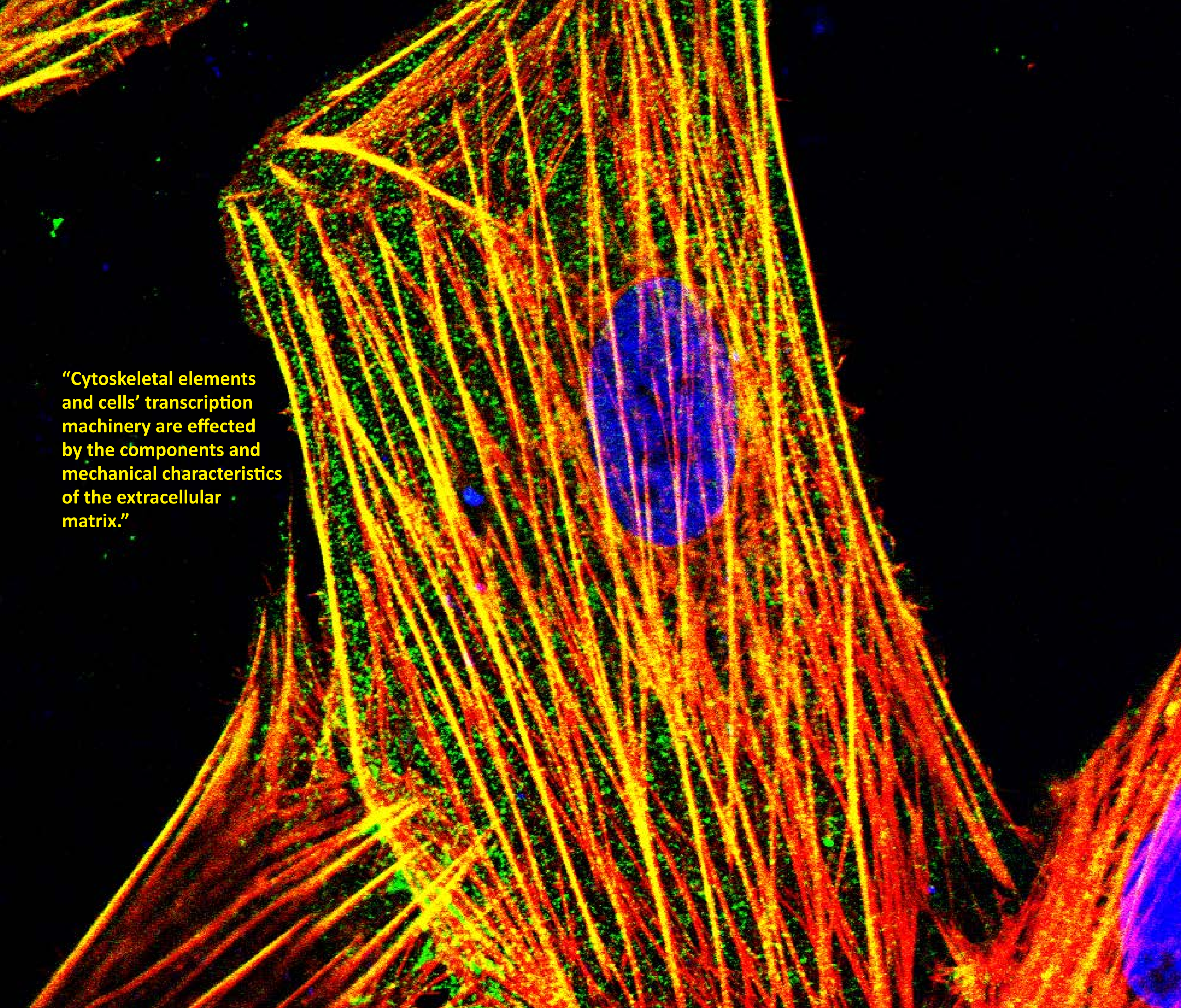
Synthetic biology is changing our view for designing of new organisms with synthetic gene expression and its synthetic regulations for a desired functionality. Synthetic biology is aiming to engineer both native metabolic pathways and exploring novel pathways in an organism for advanced well controlled functionality. Systems biology catalogs novel parts, metabolic networks, and regulatory strategies from various organisms these are being exploited by synthetic biology. In synthetic biology applications each functional genetic part was considered as a component in a circuit. Synthetic circuits are formed using genes/proteins and genetic regulation elements. To form a genetic circuit well characterized biological parts from various organism can be exploited. Some of these parts are nucleic acids, genetic regulatory elements and proteins. Combining these biological parts logic gates, memory units, biological switches (e.g. toggle switches), biological oscillator, biological devices those can make computations can be formed. A genetic language to program cellular functions can be achieved as well. All the biological devices under the control of a cellular program can achieve highly complicated tasks for a certain function.

Currently we are designing genetic circuits for nanotechnological, biomedical and biotechnological applications. We are utilizing biomaterial synthesis genes from various organism to create a synthetic circuit for single pot nanomaterial/biomaterial synthesis and functionalization. Synthetic whole cell sensors for biomedical, food and environmental monitoring is also another topic we are focused on. We are building gene circuits to mimic the biological conductivity to integrate with lab-in-a-cell systems (an integrated cellular platform with many sensory gene circuits) those can communicate with electronic interfaces through engineered conductive biofilms. Additionally we are exploring synthetic biology tools to build electro-genetic and opto-genetic systems for biotechnological / biomedical applications.



Dr. Urartu Şeker

"Synthetic Biology will revolutionize many areas by providing the richness of the life sciences as a tool for research and industry. Nanotechnology and materials science will benefit a lot from synthetic biology at the nano-biointerface."



“Cytoskeletal elements and cells’ transcription machinery are effected by the components and mechanical characteristics of the extracellular matrix.”

Nanobiotechnology

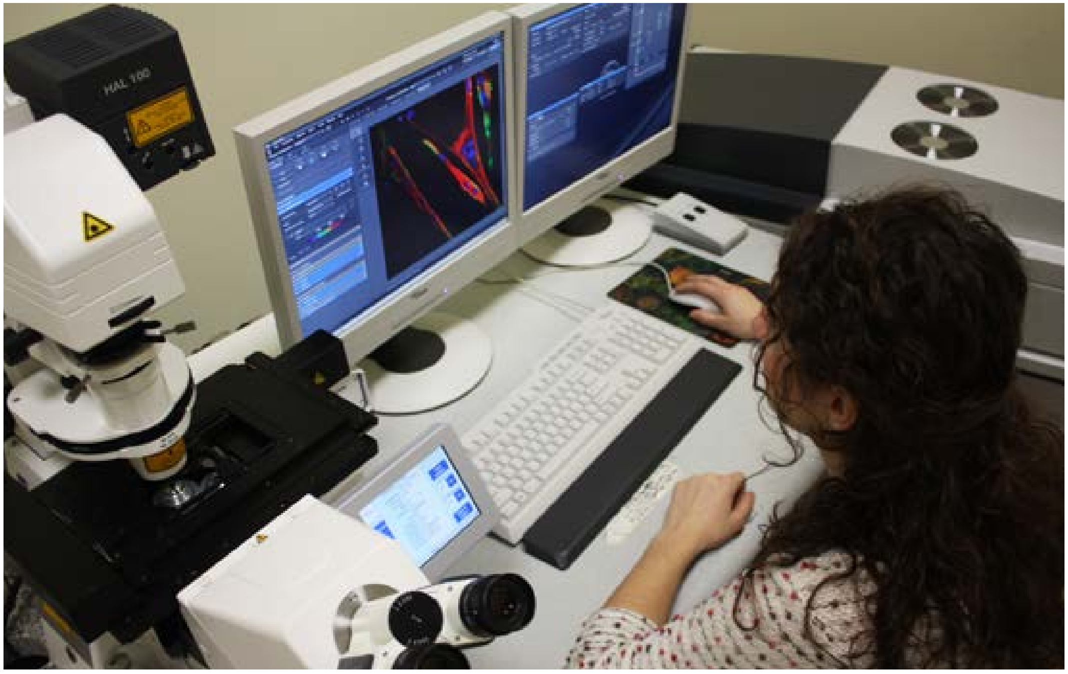
Dr. Tekinay's group works on utilization of molecular biology and nanotechnology in understanding cell-extracellular matrix interactions. These interactions are crucial for determination of cell fate not only during development but also during regeneration of tissues and wound healing. Understanding these interactions in a comprehensive manner will enable using this knowledge for regenerative medicine and drug delivery applications.

Cell-Extracellular Matrix Interactions

Since biochemical components and mechanical properties of natural extracellular matrix are highly complex and tightly regulated, we use simpler systems with selected nanosized components that form controlled platforms for studying cell behavior. Natural extracellular matrix is mainly composed of nanofibrous and globular proteins and glycans and the complexity of this environment complicates the analysis of functions of individual components. Simpler synthetic systems that can mimic the function of these components enables detailed molecular characterization of these elements.

Synthetic Platforms for Regenerative Medicine and Drug Delivery

Since prevalence of degenerative diseases increases as the population ages, development of



regenerative therapies is crucial. We use the knowledge that is gathered through analysis of molecular interactions between cells and extracellular matrix for developing novel synthetic platforms that can guide tissue regeneration in degenerative diseases and accidents. These systems alter stem cell fates and facilitate cell recruitment to damaged sites in order to assist and accelerate the process of natural healing. We also use the natural interactions between extracellular matrix components and specific cell types for developing nanosized drug delivery systems by which a therapeutic molecule can be delivered selectively to its target, hence increasing drug efficacy, reducing effective doses and minimizing toxic effects. Our group studies a wide array of drug vectors, including nanofibers, nanospheres, liposomes and SPIONs.

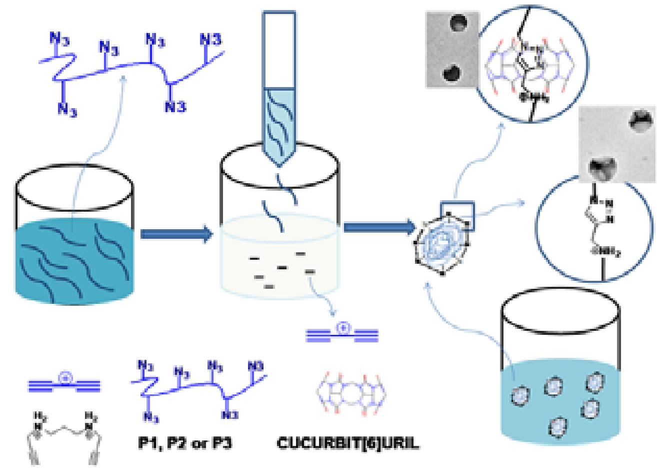
Dr. Ayşe Begüm Tekinay

Functional Organic Materials for Advanced Applications

The research in our group combines synthetic organic, supramolecular and polymer chemistry to prepare functional materials which have potential applications in the use of polymeric opto-electronic devices (LEDs, solid state lighting and photovoltaic devices), chemo- and bio-sensors, molecular switches. We are also interested in the design and synthesis of nanoparticles and nanocapsules based on light-emitting polymers for biomedical applications such as live cell imaging and theranostic nanomedicine. Here are some examples to the works carried out in our lab:

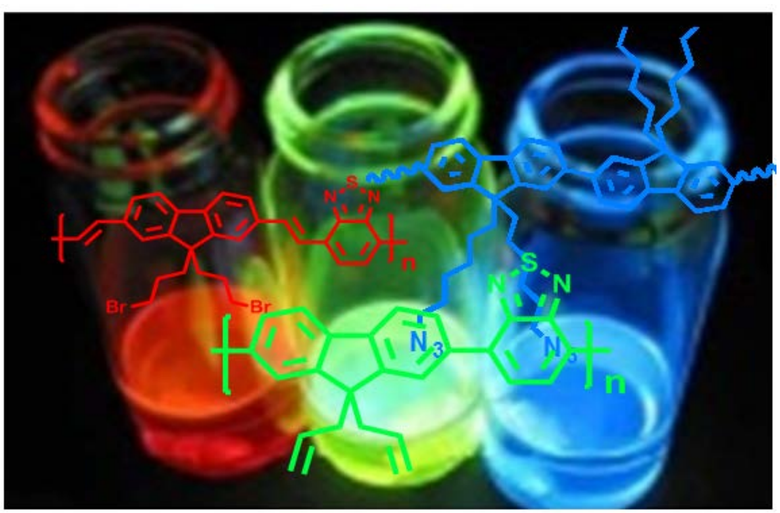
Cross-linked patchy fluorescent conjugated polymer nanoparticles synthesized by click reactions

Conjugated polymers converted into water-dispersible shape-persistent nanoparticles can be used in nanophotonics and bimedical applications.

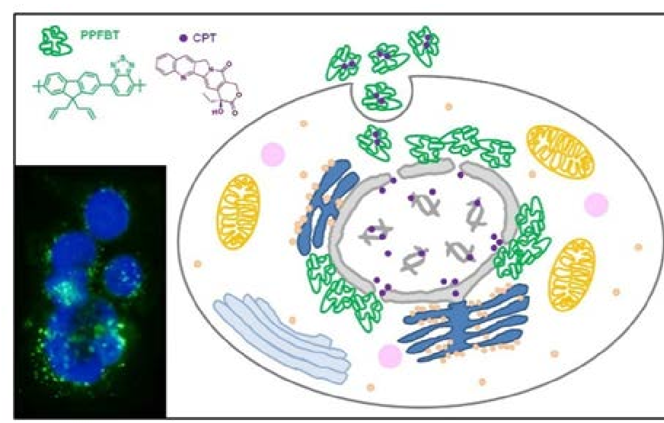


Light emitting conjugated polymers

Blue, green and red emitting conjugated polymers which contain a variety of funtional groups are synthesized and their applications are exploited in the areas of optoelectronics and chemo and biosensing.

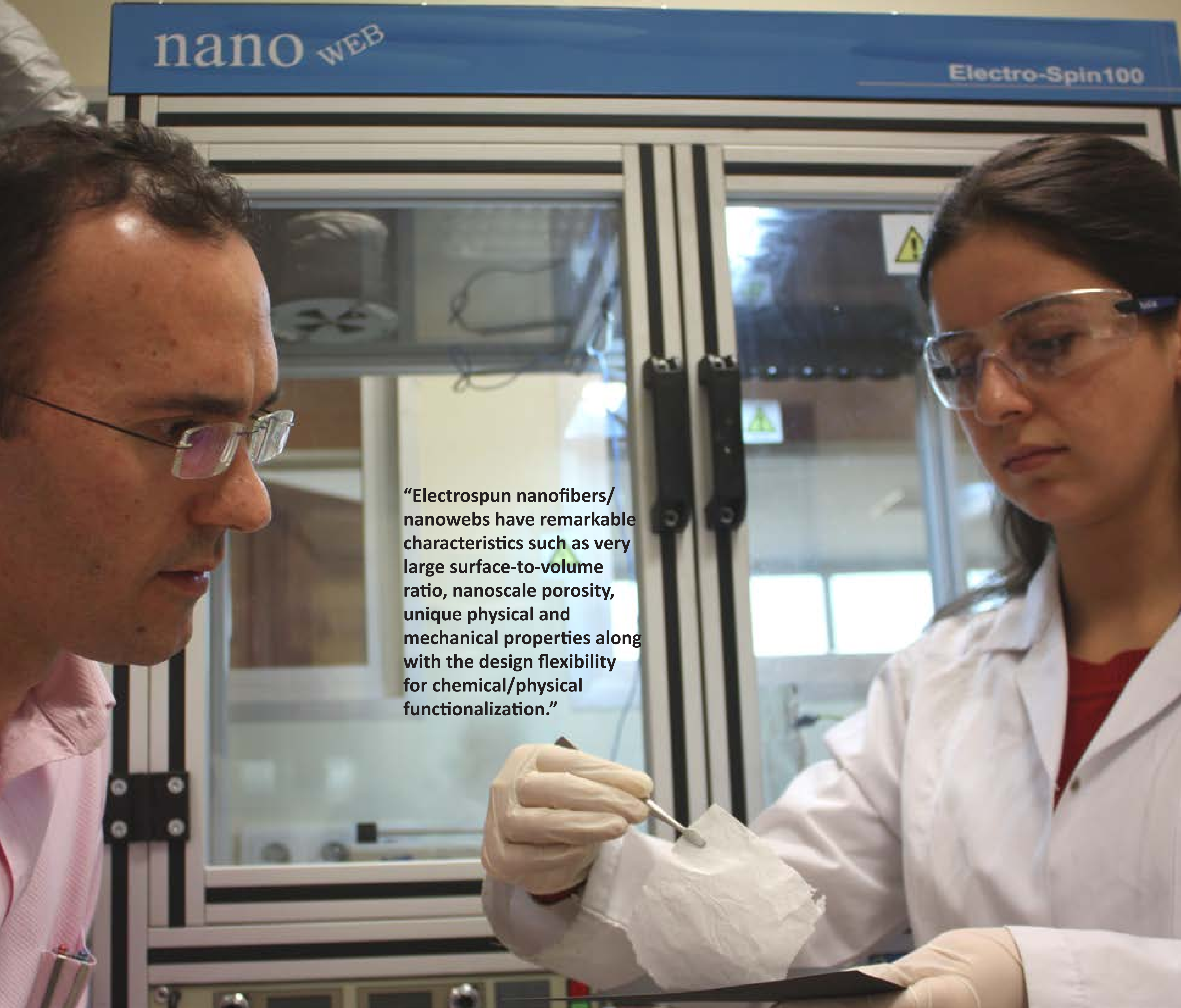


Dual functionality of conjugated polymer nanoparticles as an anticancer drug carrier and a fluorescent probe for cell imaging



Dr. Dönüş Tuncel

“Conjugated polymers synthesized in our lab are converted into nanoparticles and loaded with anti-cancer drugs for controlled drug delivery and cell-imaging.”



"Electrospun nanofibers/nanowebs have remarkable characteristics such as very large surface-to-volume ratio, nanoscale porosity, unique physical and mechanical properties along with the design flexibility for chemical/physical functionalization."

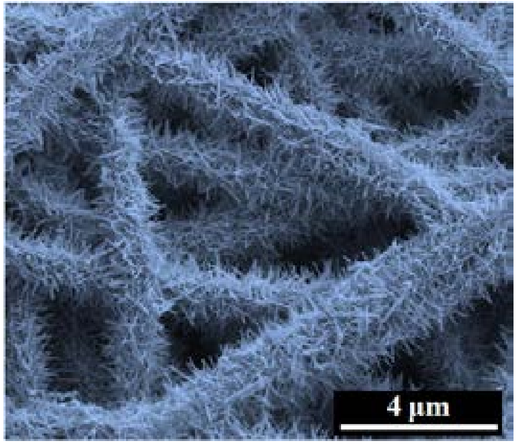
Functional Nanofibers via Electrospinning

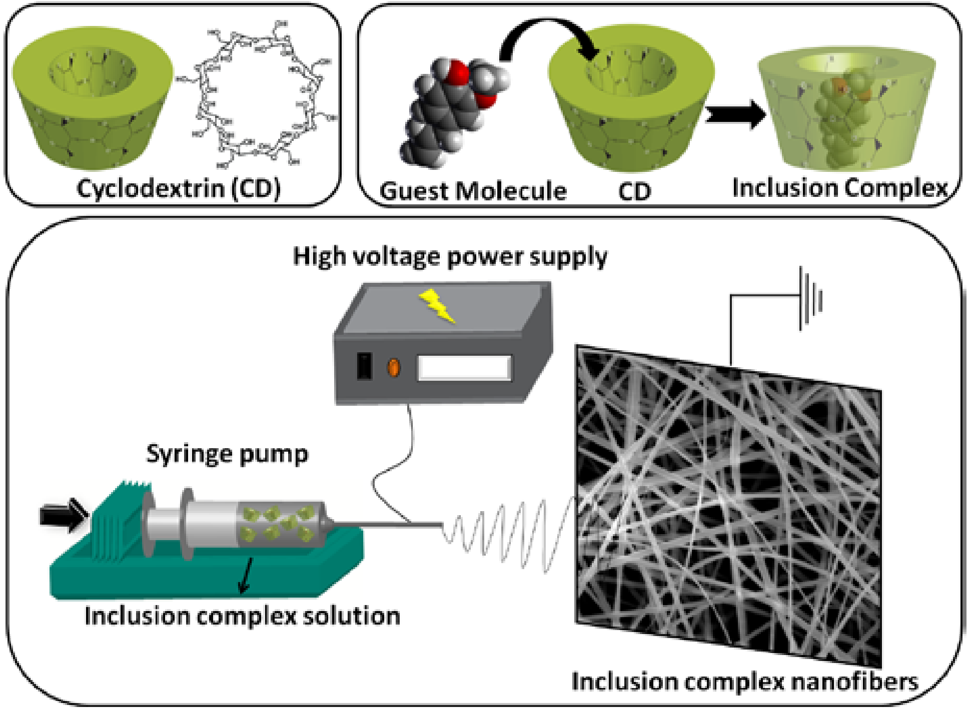
Electrospinning is as a versatile and cost-effective technique for producing functional nanofibers from various polymers, blends, composites, sol-gels, ceramics, etc. Electrospun nanofibers/nanowebs have several remarkable characteristics such as very large surface-to-volume ratio, highly porous within the nanoscale, unique physical and mechanical properties along with the design flexibility for chemical/physical functionalization. The outstanding properties and multi-functionality of these nanofibers/nanowebs make them favorable candidates in many areas including healthcare, filtration, textiles, energy, sensors,electronics, environment, food, packaging, agriculture, etc.

Electrospun Nanofibers

We have a main focus on electrospinning of nanofibers/nanowebs with novel functionalities for potential applications in filtration (molecular filters, water purification, waste treatment), biotechnology (wound dressing, controlled/sustained release systems), food and active food packaging (delivery and stabilization of food additives; essential oils, antioxidants, antibacterials), energy (solar cells, LIBs), sensors (gas sensor, biosensor, heavy metal and explosive detection, VOCs), textiles (delivery and stabilization of textile additives, protective clothing) and high performance composites.

Cyclodextrins (CD) are cyclic oligosaccharides having a toroid-shaped molecular structure. Cyclodextrins form non-covalent host-guest inclusion complexes with various molecules. CD and CD inclusion complexes (CD-IC) are already being used in pharmaceuticals, functional foods, filtrations, sustained/controlled delivery systems and textiles; therefore, incorporating CD and/or CD-IC in nanofibers hopefully extend the use of CD in the fields of biotechnology, food, filtration, textiles, etc. Uyar Research Group have special interests in Electrospinning of polymer-free CD and CD-IC nanofiber, , in addition, variety of functional electrospun polymeric nanofibers incorporating CD and CD-IC are also produced. Our research interests also cover surface functionalization of electrospun nanofiber by atomic layer deposition (ALD), electrospinning of nanofibers incorporating nanoparticles/nanostructures as well as fundamental understanding on electrospinning process and structure-property relationship of electrospun nanofibers.





Dr. Tamer Uyar

Soft Matter, Optical Tweezers and Complex Systems

Our research focuses are primarily on statistical physics, soft matter, optical manipulation, and stochastic phenomena. We are interested in both experimental and theoretical aspects. We have also been active in plasmonics, Raman spectroscopy, biophotonics, cylindrical vector beams, and fiber optics.

Nanoscience and nanotechnology are in the process of revolutionizing the way we live and do science. Micro- and nanodevices herald a new era with unprecedented possibilities in sensing and information processing at the nanoscale. Perhaps more importantly, with the development of nanotechnology comes the hope of greatly reducing the need for prime materials and manufacturing, thus leading to a much cleaner post-industrial society. In the context of this drive towards the nanoscale, the specific aim of the soft matter lab is to harness nanoscopic forces and active matter at mesoscopic and nanoscopic length-scales in order to gain a better understanding of their fundamental properties and to explore high-impact applications.

Optical tweezers

An optical tweezers is generated by a highly-focused laser beam and is capable of trapping and manipulating microscopic particles, such as cells, organelles and molecules. We are developing the optical tweezers technique so that it can explore new ranges of applications towards the nanoscale.

Measurement of nanoscopic forces

The ineluctable presence of thermal noise alters the measurement of forces acting on microscopic and nanoscopic objects, such as biomolecules and nanodevices. Our results demonstrate that the force-measurement process is prone to artifacts if the noise is not correctly taken into account. Our results are intimately connected to the long-standing issue of the interpretation of multiplicative noise in stochastic differential equations.

Active matter

Differently from passive Brownian particles, active Brownian particles, also known as microswimmers, are capable of driving themselves out of equilibrium by taking up energy from their environment and converting it into directed motion. Therefore, understanding their motion can provide insight into out-of-equilibrium phenomena associated both to biological entities such as bacteria and to artificial microswimmers. We have develop several kinds of novel microswimmers and we are employing them to explore new applications in the localization, pick-up and delivery of microscopic cargoes for, e.g., biomedical applications.

Dr. Giovanni Volpe

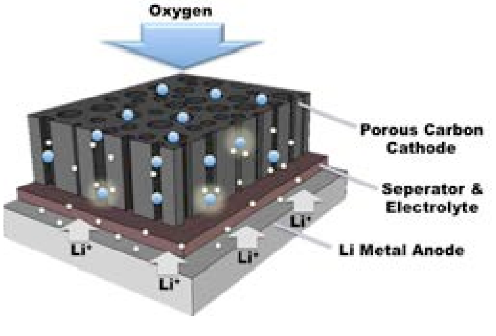
“An optical tweezers setup at work. Small microscopic particle are being trapped using a focused light beam and are tracked by using digital video microscopy.”

Electrochemical Energy Storage Systems

Energy storage has become one of the most challenging issues in recent years. Our research objective is to build "better" batteries, with higher capacity, stability and power density for various applications like portable electronics, electric vehicles and grid energy storage. We employ advanced characterization techniques and nanomaterial based synthesis approaches to develop innovative materials for batteries.

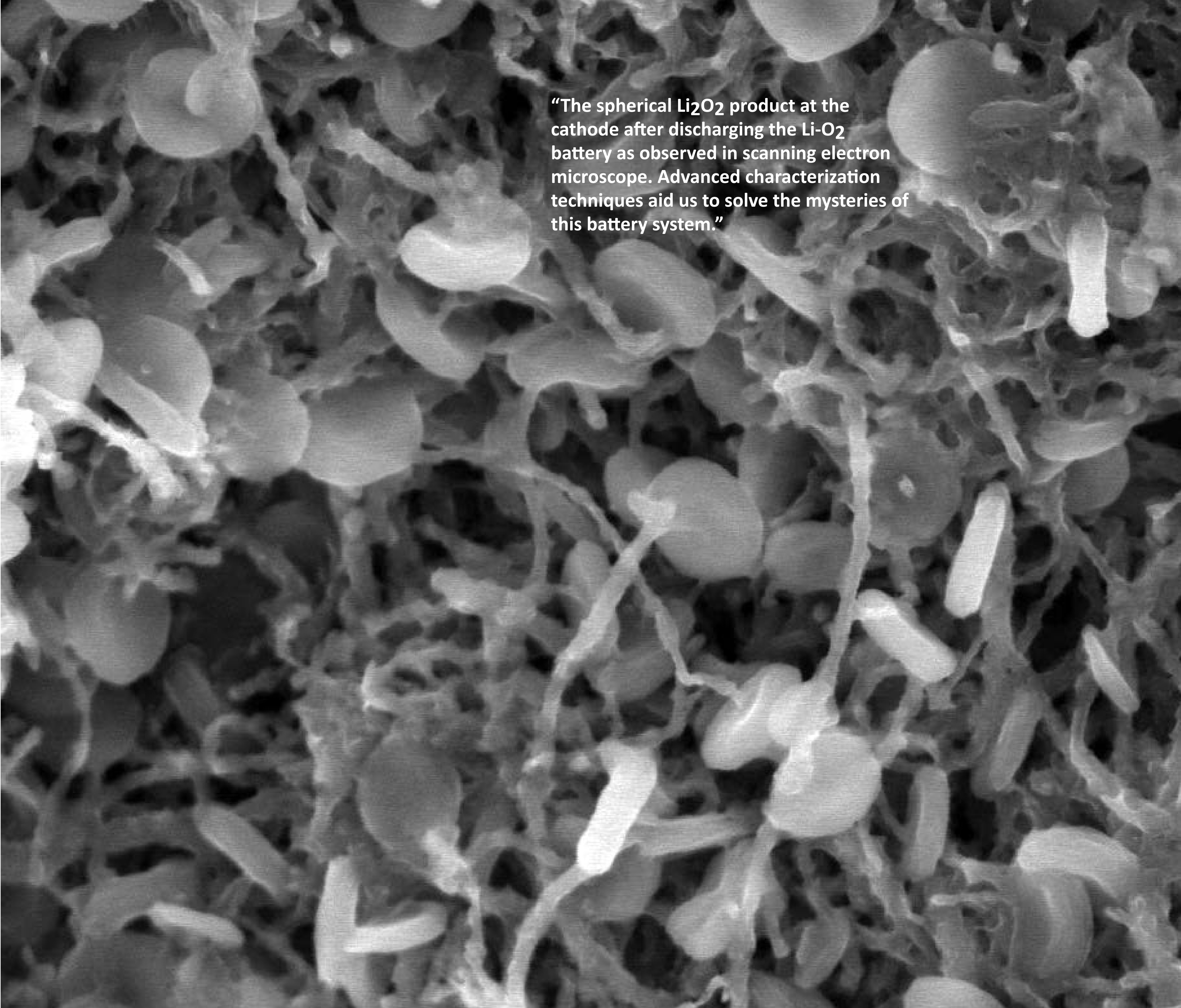
Lithium-Oxygen Battery

Lithium-ion batteries changed our perception of portable electronics when they were made commercially available in the early 90s. With the high power density and stability lithium-ion battery offered, smaller and rechargeable portable electronics were made possible. Nevertheless, the energy needs of emerging technologies are ever increasing, while the lithium-ion batteries can no longer supply the necessary energy densities needed by these new systems. Lithium-oxygen (or lithium-air) battery is a very recent and promising battery technology with 10 times higher energy storage capacity compared to lithium-ion battery. Using lithium-oxygen batteries, portable electronics with much longer usage times and electric vehicles with much extended driving ranges per charge can be achieved.



Lithium-oxygen battery discharges by the reaction of Li^+ ions with O_2 at the cathode ($2\ Li^+ + O_2 + 2e^- \leftarrow \rightarrow Li_2O_{2(s)}$ U_0=2.96 V), and Li_2O_2 is produced. Likewise, Li_2O_2 is decomposed during charging and yield Li^+ and O_2 back, completing the cycle. To accommodate discharge and charge reactions, a conductive porous cathode is used. We aim to enhance the performance of lithium-oxygen battery using nanostructured porous cathodes, tailored for the specific needs of this system. Moreover, developing effective cathode catalysts, protecting lithium anode surface from side reactions by thin film coatings and establishing the electrolyte stability are also included in our research objectives. By a multi-faceted approach to the current challenges of lithium-oxygen batteries, we're working towards to offer a viable solution for the crucial energy storage problem.

Dr. Eda Yılmaz



"The spherical Li_2O_2 product at the cathode after discharging the Li-O_2 battery as observed in scanning electron microscope. Advanced characterization techniques aid us to solve the mysteries of this battery system."

PUBLICATIONS & ACHIEVEMENTS

PUBLICATIONS

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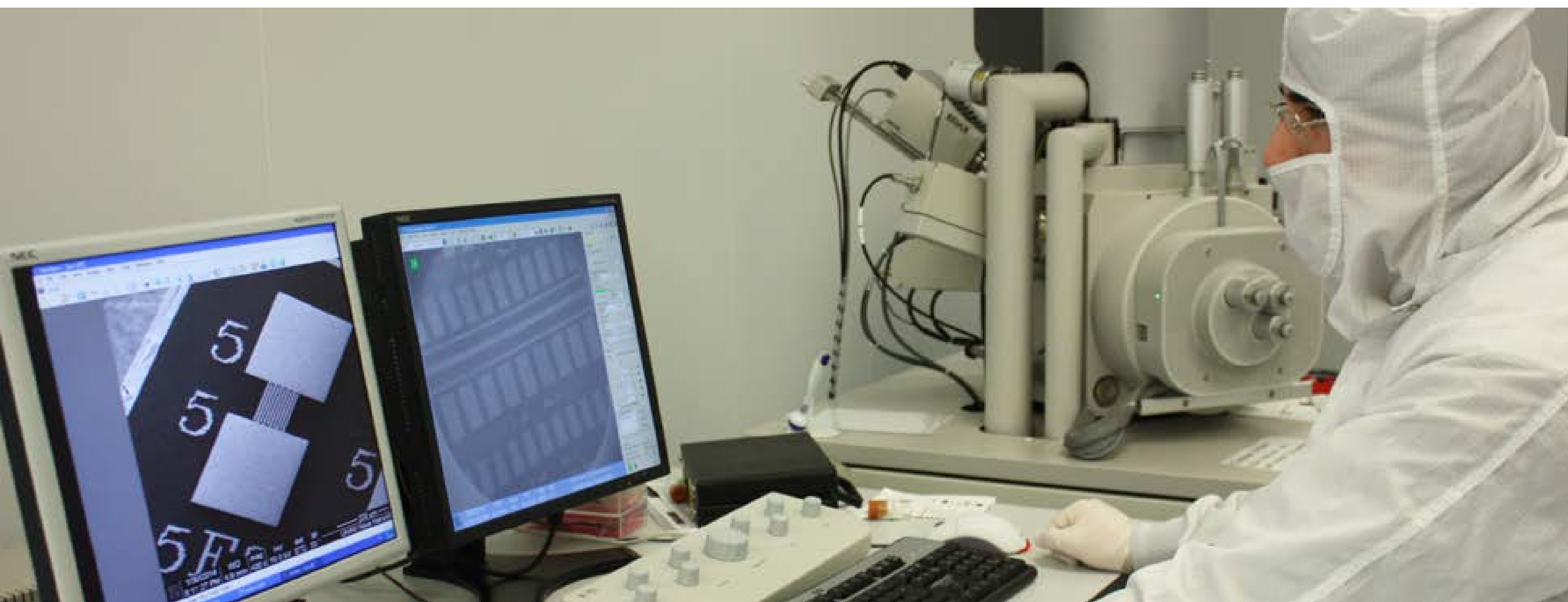


PRIZES & AWARDS

Dr. Mustafa Özgür Güler receives 2013 TÜBİTAK Incentive Award

UNAM researcher Asst. Prof. Mustafa Özgür Güler has received The Scientific and Technical Research Council of Turkey (TÜBİTAK) Incentive Award for 2013. TÜBİTAK Incentive Award is awarded to scientists, who are under the age of 40 and who have proved to have the necessary qualifications to provide outstanding contributions to science at an international level.

Dr. Engin Durgun receives 2013 BAGEP Award

UNAM researcher Asst. Prof. Engin Durgun has received 2013 BAGEP Distinguished Young Scientist Award in the field of Materials Science and Nanotechnology. The awards are given by the Science Academy Association (Bilim Akademisi Derneği) for the first time in order to recognize and support outstanding young scientists working in Turkey.

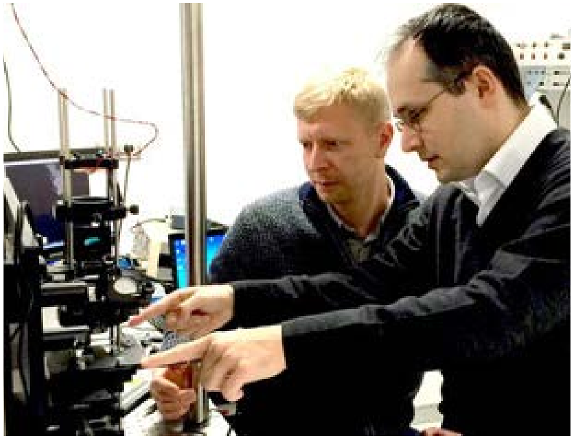
Dr. Necmi Bıyıklı and Dr. Mehmet Baykara receives 2013 Mustafa Parlar Research Incentive Award

UNAM researchers Asst. Prof. Necmi Bıyıklı and Asst. Prof. Mehmet Baykara have received 2013 Mustafa Parlar Research Incentive Award. These awards are presented to young scientists in recognition of their exceptional achievements and research productivity, in honor of the late METU professor, Mustafa Parlar.

Dr. Ömer İlday receives European Research Council (ERC) Consolidator Grant

The ERC Consolidator Grant aims to support researchers in consolidating their own independent research teams or programs. The grant is available to researchers of any nationality with 7-12 years of experience since completion of the Ph.D. and a scientific track record showing great promise.

Dr. İlday and his team have developed a method that allows creation of self-organized nanometer-scale patterns on material surfaces using a femtosecond laser. Their technique addresses a well-known problem regarding regularity of such self-organized pattern formation that had not been solved since the 1960s, allowing them to achieve unprecedented levels of regularity, even on curved or flexible surfaces. Dr. İlday has been awarded an ERC Consolidator Grant worth 2 million Euros, which will provide the opportunity to develop these concepts further. With the grant, Dr. İlday aims to demonstrate laser-controlled self-assembly of a plethora of 2D patterns, crystals and quasicrystals alike, eventually assembled layer by layer into the third dimension - an important development in the direction of a 3D material synthesizer.



Dr. Ebru Erbay receives European Research Council (ERC) Starting Grant

The ERC Starting Grant supports up-and-coming research leaders who are preparing to establish teams and begin conducting independent research. This grant program is for researchers with 2-7 years of experience since completion of the Ph.D. and a scientific track record showing great promise.

The 1.5 million Euro Starting Grant received by Dr. Erbay recognizes her contributions to understanding the molecular basis of atherosclerosis, a vascular disease that is the leading cause of heart attacks. Dr. Erbay's research group will explore the close molecular integration between the metabolic and immune systems that is required for systemic homeostasis and dysregulated in atherosclerosis, diabetes and obesity. Using a wide range of interdisciplinary approaches such as chemical genetics, transgenic mice, proteomics and RNA sequencing, they will aim to identify the precise molecular mechanisms linking metabolic stress to immune activation, discoveries that would pave the way to novel therapeutic approaches to this devastating disease cluster.

OUTREACH

WORKSHOPS

3rd International Workshop on Cleanroom Training for Critical and Sustainable Technologies - Renewable Energy
24 June - 6 July 2013

The workshop was a collaborative initiative of UNIDO and UNAM, and is supported by the Turkish Ministry of Science, Industry and Technology, Turkish International Cooperation & Coordination Agency (TİKA), and Turkish Ministry of Development. The first week of the workshop was devoted to lectures, seminars and technical visits to cleanroom laboratory facilities. In the second week, hands-on laboratory practice in UNAM Cleanroom Facility and tool presentation & demonstration sessions by equipment vendors were carried out. At the end of the program, the successful participants were handed certificates signed by UNIDO, Ministry of Industry and Trade, and UNAM. Our cleanroom coordinator, Dr. Necmi Bıyıklı, overviewed the laboratory installation, infrastructure and gave a cleanroom safety seminar.

50 researchers from 19 different countries

After the seminars, the participants enjoyed themselves during the one-day Cappadocia excursion. The program ended with a closing dinner with common remarks that this program should be a starting point for new collaborations and bilateral cooperation.

Nuclear Magnetic Resonance Workshop
10-11 October 2013

An NMR Workshop was organized with Bruker Biospin, Anatek, Bilkent University, UNAM, UMRAM & FMP Berlin.

The aim of this workshop was to increase the NMR knowledge and awareness, for the benefit of a general audience. 65 researchers and specialists have attended the 2-day workshop. Throughout the workshops, lectures, seminars and remote NMR practice were provided to the attendees.

MSN seminar series

UNAM organized 35 seminars in 2013. Several distinguished speakers were hosted at UNAM. These seminars created a platform for exchange of ideas.

“Nonlinear Laser Lithography” seminar by Dr. F. Ö. İlday

An outlook on nanotechnology research in Turkey

The magazine “Bağlantı Noktası” published a 5-page interview made with UNAM director, Dr. Mehmet Bayındır (February 2013, issue 49). This interview shines light on the importance of nanotechnology research in order to invent tomorrow’s technologies.

Dr. Bayındır has highlighted that it is extremely important to invest into nanotechnology research in order to develop value added products. It is through niche areas like nanotechnology that Turkey can reach its goal of $25,000 GDP per capita in 2023.

TRT Radio-1 hosted three UNAM researchers on the series “The World of Science and Technology”

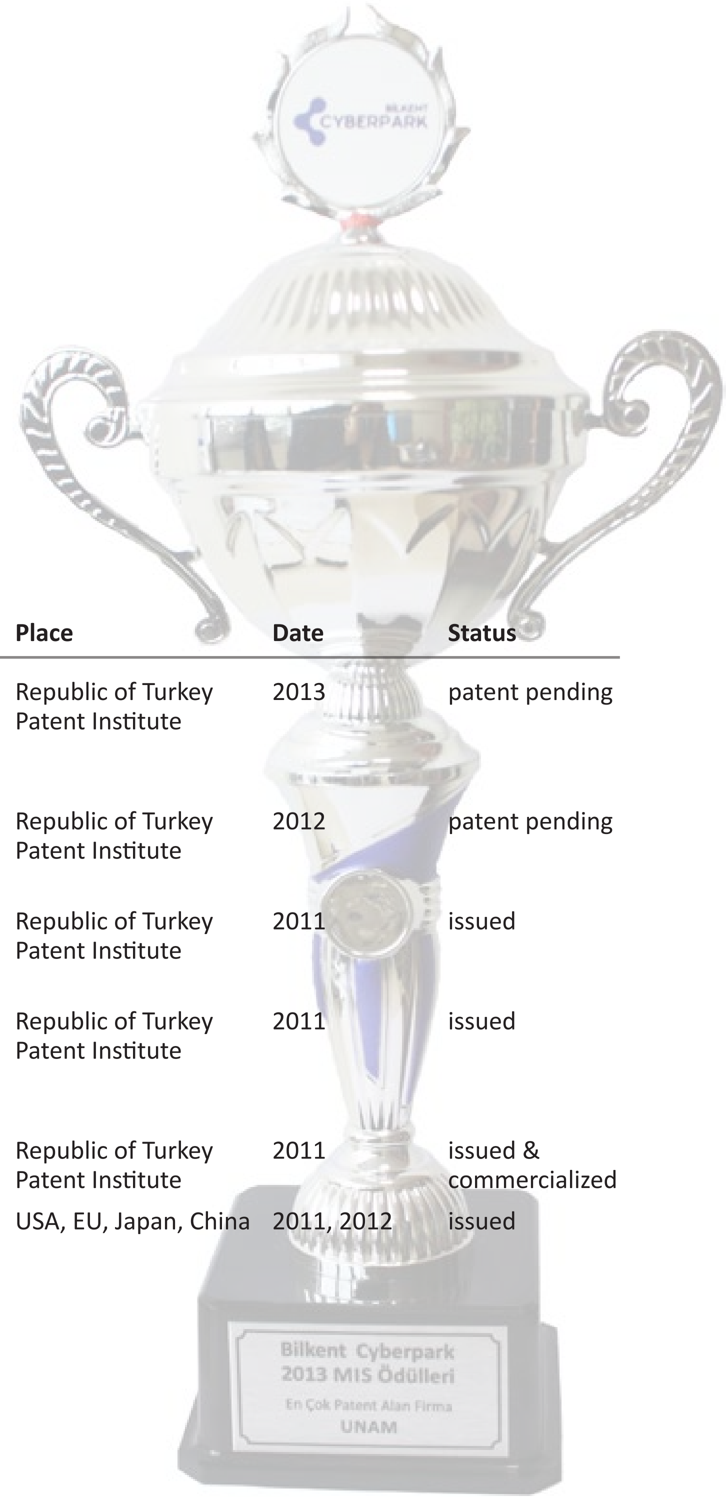
Dr. Ali Kemal Okyay - Optoelectronic applications of nanotechnology

Dr. Bülend Ortaç - Lasers and applications

Dr. Engin Durgun - Computer aided design and simulation for nanotechnology

RECENT PATENTS

On 25 December 2013, UNAM received Cyberpark "The company with the most patents" Award



Patent Number	Author(s)	Title	Place	Date	Status
TR 2013/01349	H. V. Demir et. al.	Enhancement of magnetic resonance image resolution by using bio-compatible, passive resonator hardware	Republic of Turkey Patent Institute	2013	patent pending
TR 2012/02559	H. V. Demir et. al.	Large and photosensitive nanocrystal skin and manufacturing method	Republic of Turkey Patent Institute	2012	patent pending
G-104575	M. O. Guler, A. B.Tekinay	Dopa Conjugated Peptide Nanofibers for Bioactivation of Metal Implant Surfaces	Republic of Turkey Patent Institute	2011	issued
G-16885	M. O. Guler, A. B. Tekinay, R. Mammadov, B. Mammadov	Heparin Mimetic Peptide Nanofibers for Growth Factor Binding	Republic of Turkey Patent Institute	2011	issued
G-149978	A. Dana	Plasmon Integrated Sensing Mechanism	Republic of Turkey Patent Institute	2011	issued & commercialized
US 2012122668 EP 2294014 JP 2011519720 CN 102164860	H. V. Demir et. al.	A photocatalytic nanocomposite material	USA, EU, Japan, China	2011, 2012	issued

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