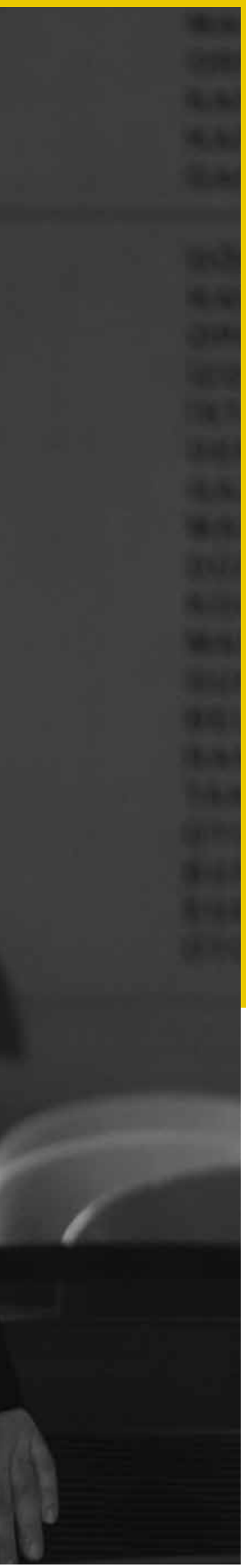
PROF. HİLMİ VOLKAN DEMİR

n²STAR Director

About Prof. Hilmi Volkan Demir

Hilmi Volkan Demir received his BS degree in electrical and electronics engineering from Bilkent University in 1998 and MS degree (Edward L Ginzton fellowship) in 2000 and PhD degree (Intel-Stanford fellowship) in 2004, both in electrical engineering from Stanford University, California, USA. Currently, he holds appointment as a chair professor of materials science and nanotechnology as well as of electrical engineering and physics at Bilkent University and UNAM. Based on agreement with Bilkent, he is also assigned to Koç University n²STAR. Concurrently, as an NRF Fellow of Singapore, he is a professor of electrical engineering, physics and materials science at NTU Singapore. His current research interests include nanocrystal optoelectronics, the science and technology of semiconductor lighting, and implantable RF electronics. Dr Demir published over 350 peer-reviewed research articles in major scientific journals, 125 of which belong to Nature Index Journals. He co-authored (together with S. Gaponenko) a textbook on Applied Nanophotonics published by Cambridge University Press (2018). He has delivered over 250 invited seminars, lectures and colloquia on the topics of colloidal nanophotonics, LED lighting and RF sensing in industry and academia around the globe. His scientific and entrepreneurship activities resulted in important international and national awards including NRF Investigatorship Award, Nanyang Award for Research Excellence, European Science Foundation EURYI Award and TÜBİTAK Science Award. He is presently the Springer-Nature Series Editor of Nanoscience and Nanotechnology since 2013 and is on the ACS Photonics Editorial Board since 2020 and was an editor of Optics Express (2014-2020). He is elected as a Fellow of The Optical Society (Optica, formerly OSA) in 2019 and Fellow of Institute of Electrical and Electronics Engineering (IEEE) in 2020.



Open Science without Borders

Click to watch a clip from the interview.

Koç University launched the Nanofabrication and Nanocharacterization Center for Advanced Scientific and Technological Research (n^2STAR) in 2021 to develop solutions to some of the world's complex problems through science with a trans-disciplinary approach. The center also will enable researchers in Turkey to conduct projects at international standards and drive high-impact innovation. n^2STAR Director Professor Hilmi Volkan Demir provides more information on the center's activities.

Koç University launched the Nanofabrication and Nanocharacterization Center for Advanced Scientific and Technological Research (n²STAR) in 2021 on the Rumelifeneri Campus. The center welcomed 2022 with 2,200 hours of machine use, 1,360 hours of advanced one-on-one training, and over 2,650 sample analyses already completed. As the activities continue at full steam, n²STAR will open its doors to all researchers for high-impact innovation.

n²STAR houses a clean room, an environment in which the number of particles is controlled in terms of cubic volume and units. So, a clean room enables building devices in a precisely controlled environment.

Powerful Infrastructure Meets Advanced Technical Knowledge

What makes n²STAR stand out the most is that it provides an infrastructure for researchers to develop projects at international standards and offers advanced technical knowledge. The center is shaped with a clean room at its core and other infrastructures in its periphery. These infrastructures function as instrument parks where advanced techniques can be applied to carry out characterization and processes. Making these instruments openly available plays a critical role in a university's capability to conduct cutting-edge research.

The clean room and its periphery accommodate some 100 pieces of equipment. In addition to shared use, the equipment is open to relevant faculty members, their research groups, and private users through bilateral agreements. These research groups from the Engineering, Science, and Medical Schools can work on their own projects within the existing system. The availability of this infrastructure enables research groups to conduct internationally-competitive studies on their subjects of choice. When such an infrastructure is not available, research groups, if any, are unable to carry out studies at international levels, meaning that they fail to win awards when they compete abroad because of their limited infrastructure.

n²STAR also offers a superstructure, which means that a technical team must master these instruments. A team with advanced technical knowledge is needed for the graduate students to carry out their thesis work using these instruments. The center hosts both the infrastructure and superstructure and makes them available for all users.

The Clean Room and Qualified Equipment

The clean room of the center is an environment in which the number of particles is controlled per unit cubic volume. This means a clean room enables building devices at the chip scale in a precisely controlled environment. When such an environment is not available, the devices may be contaminated with unwanted particles or chemicals. In such cases, the device either does

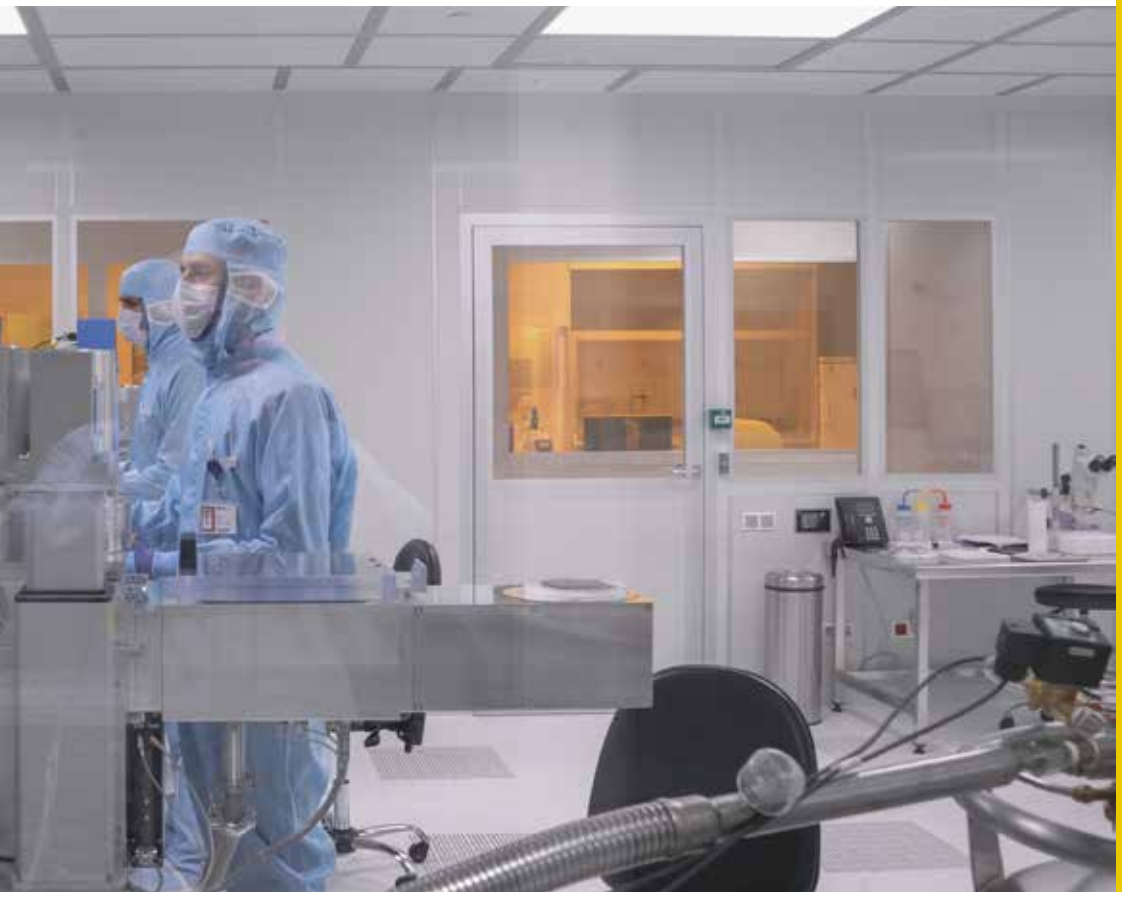
not function or its performance drops significantly. Another feature of the clean room is its high interior pressure, which means that any potential leaks flow outward and external particles never enter the interior, keeping the number of particles inside under control. The third feature is "laminar flow," or a continuous flow from top to bottom. This type of flow ensures that any particles formed within the environment are pulled downward quickly. As a result, efficient and high-performing devices can be built.

n²STAR's clean room houses tools that can be used in basic fabrication steps such as patterning, etching and coating. The characterization tools in the clean room are used to determine the accuracy of these processes.

Some physics, chemistry, biology, electrical and electronic engineering, mechanical, and chemical engineering and medicine topics require nanometric imaging. Therefore, n²STAR's infrastructure becomes critical because it offers the capability to conduct research on these topics. The existing infrastructure makes it possible to design alternative energy, biomedical materials and devices, as well as information technology chips, carry out the relevant fabrication processes, and perform some of the necessary measurements. As such, n²STAR addresses diverse fields, including energy, communication and information technologies, medical devices and healthcare.

Reverse Engineering and Product Innovations

n²STAR has plans to work closely with private sector stakeholders that



A CLOSE LOOK AT NANOFABRICATION AND NANO-CHARACTERIZATION

Let's explain the basic concepts first. What are the meanings of nanofabrication and nanocharacterization? Nano is a prefix (meaning 10^{-9}) and the nanometric scale means one billionth of a meter. Fabrication on this scale can result in unique structures that may not be normally found in nature. In this process, called "nanofabrication," you can go down to the atomic scale. In other words, when you process a surface on a nanometric level and create nanometric patterns, you also can build advanced devices on a chip. Similarly, when you characterize on the same scale, you can understand the various properties of a specific material or a device's material and analyze the elements. So, nanocharacterization is essential as a capability complementary to nanofabrication. When these two capabilities are combined, structures that are normally impossible become understandable and doable.

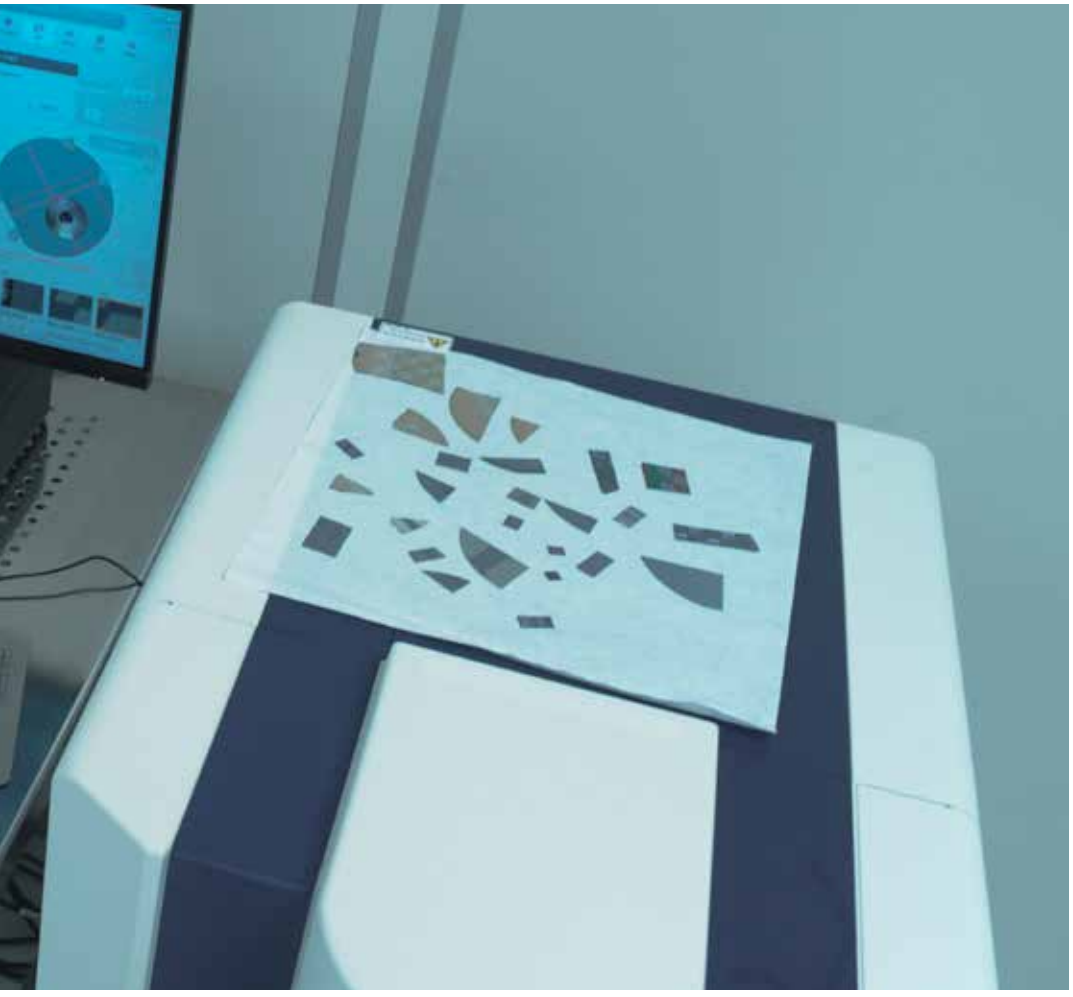
HİLMİ VOLKAN DEMİR ON HIS RESEARCH

While studying toward my PhD at Stanford University, I worked in a laboratory environment where different disciplines came together. The infrastructure was similar to the one at Koç University. My research focus is on photonics, meaning that I am studying the interaction between photons and electrons, in specific materials and structures. These studies involved light generation, light-harvesting, and energy transfer on both the quantum material level and devices made from such materials. For instance, our group makes light-emitting diodes (LEDs) from different materials. Our work spans a wide range from material design and production to device engineering, fabrication, and system-level operation for informed deployment. This vertical integration research model covers the entire food chain end-to-end and enables us to innovate and enhance the value of our work. Our group has more than 50 inventions under its belt and more than 110 patents. The innovative products born from these studies have paved the way for the establishment of four successful businesses. Working with both R&D companies and other businesses, we have so far created more than ten deep-technology products through cooperation and co-creation.

may need this type of infrastructure. The clean room and the infrastructure in its periphery along with the complementary superstructure will make it possible for these stakeholders to perform highly advanced reverse engineering, which means having the opportunity to analyze and understand competitors' products in depth. Companies in Turkey can work with n²STAR to follow their international competitors' products, understand their technologies, and develop their own as needed. This represents a significant economic advantage for Turkey. In addition to reverse engineering, developing innovative products and fabricating them, especially on the material and device levels, require an infrastructure as capable as that of n²STAR.

A Trans-disciplinary Approach to Solving Complex Problems

To date, more than 100 researchers, including 30 faculty members, have benefited from the center. According to the user portfolios of these researchers, their studies focus mainly on engineering, sciences, and medicine. In other words, n²STAR provides an environment where these three disciplines intersect. Beyond interdisciplinary work, the available infrastructure allows a trans-disciplinary approach to solving problems. Thus, n²STAR enables the intersection of different disciplines and the use and combination of the diverse methodologies of different disciplines, making it possible to generate solutions with a holistic approach to problems.



Problems today are quite complex and most of the time, it takes more than one discipline to come up with a solution. Therefore, the trans-disciplinary approach of n²STAR creates a significant advantage for researchers. But this is not all. The center also embraces an open-minded approach, ready to welcome co-working opportunities with other research centers within Koç University and external partners.

Driving Science in the Right Direction

n²STAR champions a scientific philosophy of open science in every aspect to eliminate the borders between departments, disciplines, campuses, and countries. In this sense, the center is defined as an excellent academic environment for joint studies in Turkey and around the globe. In addition to academics, n²STAR also has private and public sector stakeholders. n²STAR believes that interconnected and collective studies in a network will play a key role in driving science for humanity in the right direction.