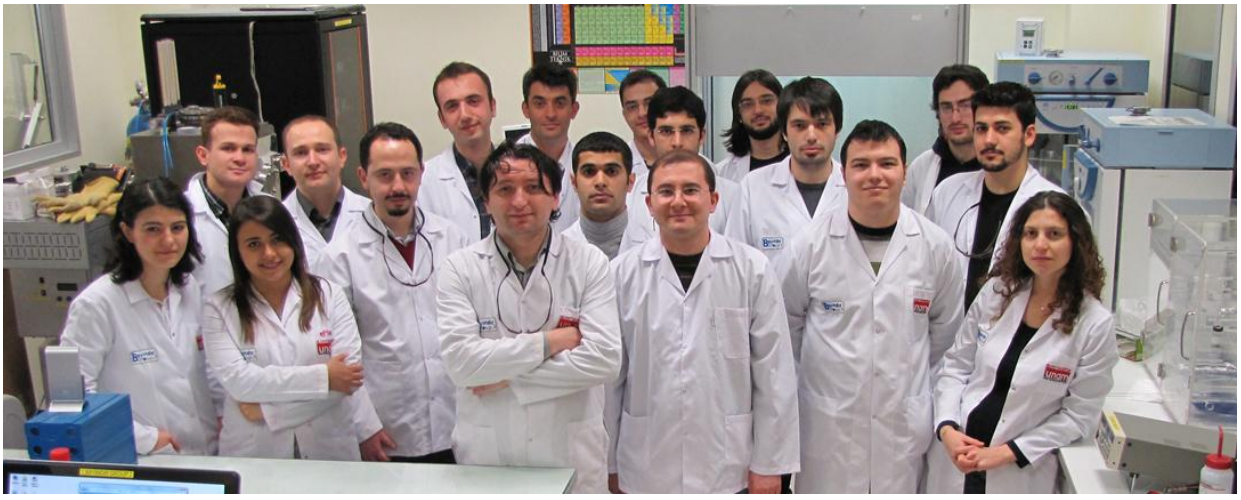
UNAM Researhers Demonstrated a Novel Nanofabrication Scheme

Handling of Kilometer Long Nanostructures: Managing nanostructures is usually considered harder than producing them. This fact is probably about to change.

July 2011 issue cover of Nature Materials hosts a remarkable achievement in nanotechnology. Bayindir Research Group, working under supervision of Professor Mehmet Bayindir at UNAM-National Nanotechnology Research Center at Bilkent University, has recently accomplished production of indefinitely long nanostructures embedded in protective polymer fiber. The method clearly has the potential to revolutionize the nanowire research.

Dr. Mecit Yaman, the first author of the article, describes the significance of their work: “Fiber and fiber drawing has always been making headlines. It is worthwhile to mention the Chinese silk as the first fiber material, that was so much in demand that it has an eponymous trade route. Lets skip Chinese and start with Sir George Stokes. A rare genius that is perceptive to both mathematics and experimentation he found much interest in explaining the viscoelastic behaviour of the drawn fiber, what is today known as the Navier-Stokes equations. Interest in one dimensional materials peaked in the 1970’s again, this time for alltogether different reason. Kilometers of glass threads drawn from a prefrom were in the spotlight for their potential in high speed, high bandwidth telecommunications -the backbone of the high speed internet. His efforts for developing the fiberoptic cable brought Charles Kao the Nobel prize. Only two decades later, the advent of photonic crystals, once again brought extreme glass wires back into research laboratories. This time a novel light guiding was the focus of interest. The point I’m trying to make is that fibers, extremely long extremely thin wires drawn from a simple preform, always



meant something different, something novel, with the changing soul of the times. In the age of nanotechnology, it is then only natural to think of them as 'indefinetly long nanowires.' Now that is the beginning of something rich, dangerously rich."

Thermal drawing was reintroduced into nanotechnology with this study, but this time iteratively. By heating and pulling together the products of each thermal drawing step consecutively, the researchers ended with kilometer long nanostructures. "We develop a new fabrication techniques for production of infinite aspect ratio, easily handled nanowires and nanotubes. Using our novel fabrication technique we fabricated infinitely long polymer encapsulated semiconductor, metal nanowires and piezoelectric nanotubes," says Mehmet Kanık, a graduate student who spent a lot of days and nights while drawing the fibers, to describe their approach. "The resulting structures are truly unique in many ways. They are nanosized in diameter and embedded in a flexible polymer jacket. They are ordered and their length extends for meters. The structure is reminiscent of the organic building blocks we see around us in trees for example, tiny fibers making up the strong trunk of a tree. The structure has the potential to function as an active device and support itself. For example you can use it as a nanofluidic channel for ion transport, or as a microfluidic reactor, or for light to electricity conversion. You can use its optical features to mimic the iridiscent colors of beetles, peacocks, etc. The most interesting feature of the in-fiber nanowires to me is that is that they are large area nanostructures," Mecit Yaman says.

There is still lots of work to do. Even before the article was submitted, researchers had begun studying utilization of these nanostructures in novel applications. Dr. Hakan Deniz, another author of the article says "I believe the technology we developed here has a very high chance to change the route of nanotechnology, maybe in ten years". "Besides using these 1-D nanostructures in current nanowire based micro/nanophotonics applications, it will also open new doors of applications in optics. Structural coloring in nanowires based on different working principles, generating different gaussian-legendre type beams for optical tweezing purpose with accurately located nanowire array, biomimicking , nonlinear nanophotonics are some of appeared observation in these nanowires," says Tural Khudiyev, another graduate student who has his research focus on optics and photonics, but is also fabricating his own fibers.

Electronics is another field of interest, which limits are indefinite. Erol Ozgur and Ozan Aktas are two graduate students working in collaboration for exposing the semiconductor characteristics of these nanowires. Erol comments that "Being able to produce semiconducting nanowires and assemble them into functional devices is the key to be considered succesful in nanowire research,

because otherwise your work could easily be underrated. We are currently developing novel large area sensors and nanowire phase change memory devices; the work we presented in the Nature Materials article is only the beginning." Piezoelectric nanotubes could also be produced via this method. "We will use these tubes as artificial muscle for biomechanical and robotic applications. When you take a closer look at muscle structure you can easily notice that the structure of our nanotubes in a PSU jacket is just same with muscle structure," says Mehmet Kanık.

Let's have a few words about the environment where this research emerged. Bayindir Research Group is located in UNAM, the most sophistigated nanotechnology research facility of the Turkey and the Middle East. Young scientists, including the principal investigator Mehmet Bayindir, maintain an excellent teamwork. "I believe that, this research was accomplished by well-organized, disciplined and hardworking researchers. Our strong interaction and group study was one of the significant factors that speeded-up resulting this high quality research successfully," Tural Khudiyev says. "We -for it is a teamwork- realized that what we have in hand, when developed, could become something extremely important -that is nanowire making with fiber drawing. The insight, followed by a couple of years' unwavering focus, and a good amount of luck, usually delivers worthwhile results. Experimental work is always surprising," Mecit Yaman comments.