future by semcon

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DIFFICULT MADE SIMPLE

Emma Sweet makes sure Jaguar Land Rover's advanced cars are easy to use

- EFFECTIVE DELIVERY WITH A CLASSIC BUSINESS MODEL
- VOLKSWAGEN WANTS TO BE THE WORLD'S BIGGEST
- VOLVO'S NEW CONCEPT CAR BUILT IN RECORD TIME

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EDITORIAL

Efficient delivery

We have grown together with our customers and we continue to grow. Our focus is on constantly delivering added value and therefore we continue streamlining our processes to be the professional partner our customers need.

In this edition of Future by Semcon our theme is front office and back office (FOBO). It is an approach that we increasingly work with. In other words, we are as close as possible to our customers while seeking out and employing the best talent wherever it is located. With FOBO we are able to deliver cost-effective services while not only being in our customers' immediate vicinity but also giving them access to specialists worldwide. By being close to our customers we get to know them and can see what their needs are and then develop the best skills. The important thing for us is that customers can rely on us and therefore concentrate on their other activities. This is a model that we believe in and that we and our customers are happy with.

WE ARE ALSO very proud that Dr Ulrich Hackenberg, Volkswagen's head of development, is part of this issue. He talks about Volkswagen's objectives and about working with us. You can also read about Semcon's contribution to the development of the Universe, Volvo's concept car and BiFi, a development project that we, with our technical knowledge, are running with the Swedish Transport Authority.

KJELL NILSSON CEO, SEMCON

Q&A **ILHAN AKSAY**
BATTERY RESEARCHER

Batteries are the great stumbling block in the development of electric cars. Batteries are too expensive, and they take a long time to "refuel" - who wants to wait several hours for a car to recharge? However, professor **Ilhan Aksay** from Princeton University has shown that it's possible to shorten this charging time dramatically. The trick is the "super material" graphene.

TEXT **INGELA ROOS**
PHOTOS **MARTIN OLOFSSON**

It took only six years before the discoverers of the "super material" graphene were awarded a Nobel Prize, in 2010. This is exceptionally quick for a Nobel Prize - most of the winners are elderly gentlemen who made their pioneering efforts several decades previously. But then graphene is also an unusual material.

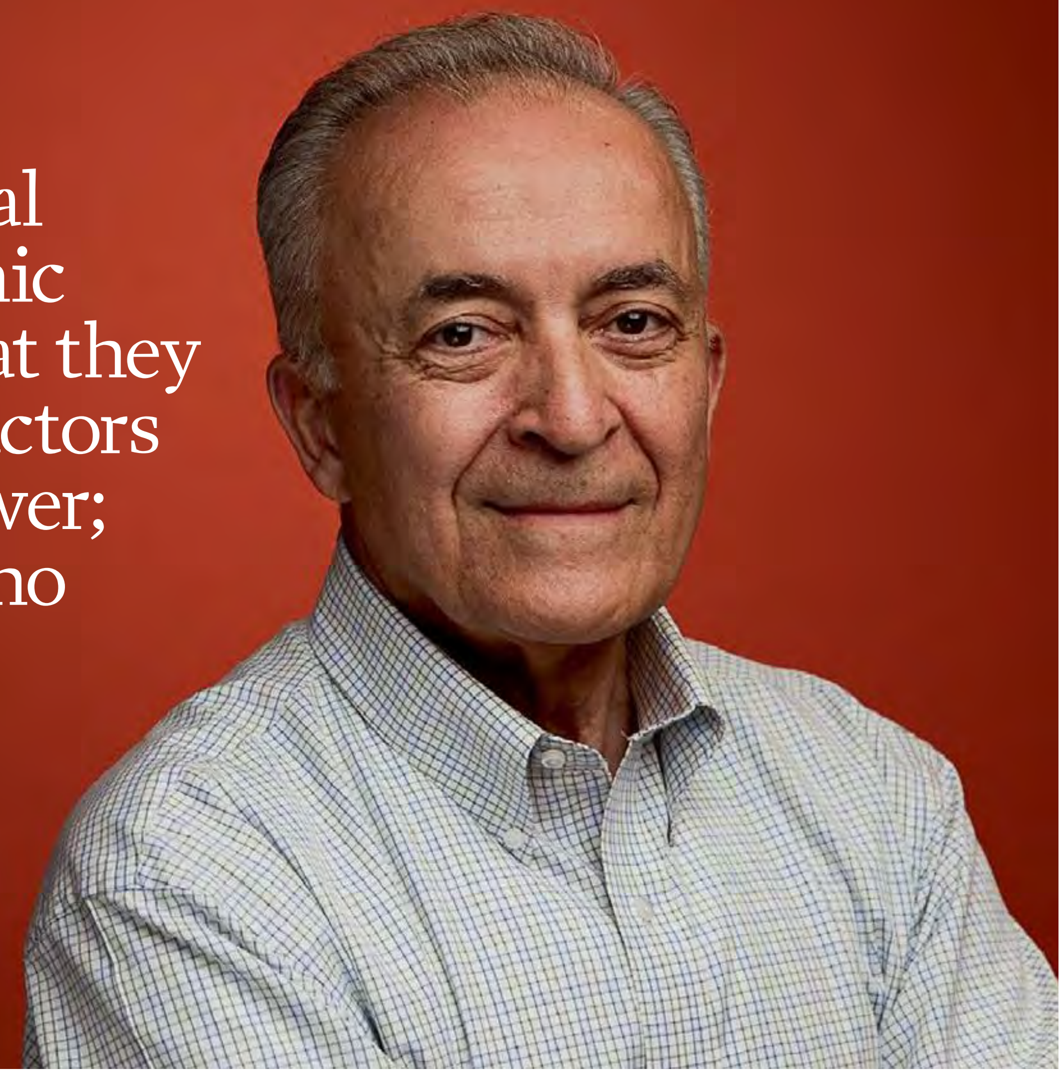
Graphene is incredibly simple — it consists of ordinary carbon atoms in a honeycomb-like structure. Graphene's uniqueness lies in its properties - it is incredibly thin, incredibly strong and has extremely good electrical conductivity. Interest in graphene is sky-high and the expected applications are in diverse areas. Graphene is expected to revolutionize the electronics industry, reinforce plastics and effectively store hydrogen for fuel cells.

While most graphene projects are still in their infancy, Professor Ilhan Aksay at Princeton University and his colleagues have already developed a completely new electrode material that greatly enhances the capacity of lithium ion batteries.

Battery scientists have long dreamed of using tin oxide as anodes (i.e. positive electrodes) in lithium ion batteries. Tin oxide is extremely good at handling lithium ions. The problem is that it is quickly destroyed when the battery charges and discharges. Ilhan Aksay and his collaborators have solved this problem by mixing tin oxide with graphene on a nano-scale. The result is a material that has both the high capacity of tin oxide and at the same time withstands the strains of charging and discharging.

“The traditional image of ceramic materials is that they are poor conductors of heat and power; that picture is no longer true.”

Ilhan Aksay,
professor, Princeton



You have developed a battery material with graphene, dramatically shortening the recharging time. How does this actually work?

“I have no definitive answer, but we think it works like this: the tin oxide conducts the ions, transporting lithium ions back and forth within the battery. But tin oxide cannot conduct electrons. Graphene is, however, an extremely good electron conductor. We combine the two materials by placing one or two layers of graphene between layers of tin oxide - it becomes like a sandwich structure on a nanoscale. This structure allows us to quickly conduct electrons in and out of the battery, and therefore charge it quickly. We are confident that our hypothesis is correct to this extent, but our explanation is still incomplete.”

What will this battery mean for the automotive industry?

“The transport sector is just one sector that will benefit from it. Lithium-ion batteries are used in many different situations. All laptops today have lithium-ion batteries and it takes at least half an hour or an hour to charge them. If we shorten the charging time to a couple of minutes it will have a major impact.”

One of the major drawbacks of today’s batteries in electric vehicles is that they are so expensive. Is your battery cheaper?

“Good question. I am not involved with the financial issues and can only guess. Graphene will not increase the cost and the battery is not likely to be more expensive than existing ones. But I’m not sure it will be cheaper.”

Is your battery on the market yet?

“Not yet. It usually takes a few years from publishing an article until there is a commercial product. The company Vorbeck, who work with Princeton University will, with the Canadian company Targray, commercialize our battery material. My experience says it will take two to five years, although business people like to think that it will be next month.”

What remains to be done before the battery can be used?

“Our work has just begun. We started this two years ago and so far we have worked on the anode. But a battery has two electrodes - an anode and a cathode. You could certainly make a battery out of our anode and an existing cathode. But if you really want to improve the battery as a whole, you have to work on the cathode as well.”

Is this the first time you have applied your materials research to battery technology?

“No, we started with supercapacitors. They also store electricity, but discharge the stored

FACTS

Ilhan Aksay

Lives: In Princeton, New Jersey, approximately three kilometres from his office at Princeton University
Family: Wife Isabelle Michel-Aksay, from Paris. His son Emre is a biophysicist and professor at Cornell Medical School in New York. His daughter Evin is a schoolteacher. He also has three grandchildren.
Qualifications: A Ph.D. in materials science and engineering from the University of California, Berkeley.
Hobbies: Hiking and gardening
Reads: Nowadays only has time to read technical articles and books
Listens to: Classical music
Published: More than 350 articles and 30 patents. Has been the editor of ten books.

energy once and very quickly."

What does the future hold for batteries?

"To completely get rid of one of the battery electrodes - it would make them much lighter. The future is very likely in lithium-air batteries, where the surrounding air constitutes the battery's cathode. Lithium and graphene are the active components of the anode. We are involved in the work on materials for these batteries as well. It looks very promising, but it is, as I said, in the future. Currently, the technology is most useful in disposable batteries."

You work at the ceramic materials laboratory at Princeton. Is graphene really a ceramic material?

"Yes, according to the modern definition. But many scientists are brainwashed into believing that ceramics can only consist of silicates. I started my research career with silicates, but you have to keep up with the times. The traditional image of ceramic materials is that they are poor conductors of heat and power, and they should be hard and brittle as well. But that picture is no longer true. I work according to the guidelines of the two-time Nobel Prize winner Linus Pauling. He defines materials according to their type of molecular bonds. If all the bonds are covalent or ionic, the material counts as a ceramic, and therefore graphene is a ceramic."

What is it that makes graphene so special?

"It is a two-dimensional macromolecule, a single layer of carbon atoms. You can use it as a building block for assembling composites. You can make hybrid structures that combine the properties of graphene with those of other materials. For example, all polymers are insulators. But by inserting graphene — which of course conducts electricity — into a matrix of polymers you get a conductive polymer."

Can you give some more examples of what graphene can be combined with?

"Rubber. If you put graphene in rubber, it also becomes conductive. This is important because many rubber products would otherwise store electrostatic energy. With graphene in rubber, it becomes even more elastic. Tears and cracks are caused by defects in the rubber, and without graphene they rapidly spread. The graphene layers stop the defects spreading, but every little tear also opens up the rubber a little bit and allows for stretching. It works much like an accordion - the material that the accordion is made of is not stretchable, but the accordion is, due to its shape. Graphene plays the same role in rubber."

What use is there for electrically conductive and elastic rubber?

"Electrically conductive rubber can be used as electrodes. You can also stretch the rubber by applying an electric field to it. There is a great need for active materials that can be controlled with electric fields - it is much easier to control electric fields than, for example, mechanical forces.

An electrically stretchable rubber can be used in micro-pumps to move very small and precise amounts of liquid - such as medicines. You can also use it to detect tension. If you can create mechanical stresses in a material by using electricity, the reverse is also true."

What is the next step in your graphene research?

"We have just begun to make long strips of graphene. They are five centimetres wide and can be made more than a kilometre long. The strips are electrically conductive and highly porous. You can infiltrate various liquids into them and use them as electrodes. Or you can cover a surface with them and make the whole surface electrically conductive."

What triggered your interest in materials research?

"I was born in Istanbul, Turkey and finished high school there. For my university education, I was offered two scholarships by the Turkish Government in 1962 — one, to major in mining engineering in Germany; and the second, to major in ceramic engineering in the United States. I did not want to be a mining engineer. Although I did not know much about ceramic engineering, the excitement of coming to the United States was strong enough to push me into ceramic engineering. Thus, ceramic materials was my launching point into the greater world of materials. After earning my ceramic engineering degree at the University of Washington at Seattle in 1967, I went to the University of California at Berkeley to get a Ph.D. in materials science and engineering and continued doing research in materials ever since."

What keeps your interest in materials?

"Civilizations have evolved with materials and will continue to do so as long as we exist. The first materials produced by humans date back about 10,000 to 12,000 years. They were ceramics. Metals and organic polymers came a few millenia later. The approach we have used to produce these materials is akin to the processes used in the geological world. We pack powders to form shapes and heat them to very high temperatures (> 1,000 °C) to make them stronger by sintering processes. We melt metals and polymers to form shapes. This is what our ancestors started with and the fundamental education system in materials science and engineering, by and large, is still following this path. This geological path has severe limitations especially in the development of nanostructured materials. An alternative path is the one used by the biological world, which evolves through self-assembly at molecular levels and moves to larger, hierarchically arranged structures. They are adaptive. They are living. Over the last 40-50 years, many researchers around the world have recognized the importance of this path to produce new materials that are impossible to produce by the techniques our ancestors pioneered. I have also become a follower of this bio-inspired processing path and have been an active player on this path since the early 1980s. This is what keeps my interest in materials and I see no end to it. This path will guide us to the future."

3 dream advances in nanotechnology

1 NANOMATERIALS IN LARGE VOLUMES

Many nanomaterials have impressive features. The challenge now is to scale up the volume to a millimetre or metre scale without losing the unique properties. When we have solved this problem, many new nanotechnology products will emerge.

2 SELF-ASSEMBLING PRODUCTS

The biological world routinely creates very complex systems through self-assembly. We created an electrode for a lithium-ion battery by the self-assembly of graphene and other substances, but it is very modest progress - an electrode is far from a full battery. Can we ever get an entire apparatus to assemble itself?

3 ADAPTIVE MATERIALS

Laboratories around the world are researching how to integrate sensors, actuators and a controller in a material on a nano-scale. Sensors and actuators are relatively easy to integrate into nanostructures, but inserting a control unit must wait until we have learned to build such a device. Once we do that, we can produce truly customizable materials.