The Green Glint of Stones

Replacing silicon with diamond may significantly reduce energy losses in electronic devices, according to **Dr. Michał Pomorski** from the CEA-LIST Diamond Sensors Laboratory in France.

ACADEMIA: **Diamonds are used as an abrasive material, and of course for cutting. What other applications do they have?**

MICHAŁ POMORSKI: They are used in high-power electronics, for example, although this is in early stages of development. Our laboratory is a participant in the Green Diamond project, a four-year EU initiative launched earlier this year.

What makes diamonds suitable?

Diamonds are extremely strong mechanically and they are the hardest substance found in nature. They allow a high mobility of charge carriers and have a low dielectric constant, a high breakdown voltage and a high range of operational temperatures, theoretically up to above 1000°C. Monocrystalline diamonds also have the highest heat conductivity at room temperature of all known materials. Using diamond in electronic devices, which currently mainly use silicon, may significantly reduce energy losses. For example, in Japan there is an underground line using converters made of silicon carbide whose properties lie somewhere between those of silicon and diamond. This saves approx. 30% of energy. Using pure diamond can increase these savings to 60%, giving the environmentally-friendly technology its name: Green Diamond.

You work at a large research institution.

That's right – it's a laboratory developing diamond sensors, forming a part of the French Alternative Energies and Atomic Energy Commission (CEA). It's an extremely important organization, employing over 15,000 people in France with around 5,000 working in Saclay. I am responsible for the development of radiation detectors based on diamond technology.

What kind of radiation is this?

It's radiation which we can't observe directly and which ionizes the medium it passes through – this means detaching at least one electron from an atom or molecule, or dislocating it from a crystalline structure. Ionizing radiation includes alpha rays (a stream of helium nuclei), beta rays (a stream of electrons or positrons), high-energy electromagnetic gamma rays and, indirectly, neutrons. Ionizing radiation is generated by many devices widely used in medicine and technology, such as X-ray tubes, particle accelerators, and nuclear reactors. It's also used in diagnostics, medical treatment, and research, but it has a dark side – high doses are extremely dangerous. This means it's important that ionizing radiation is measured accurately in all instances.

Our detectors of ionizing radiation use an electronic process based on generating electrical charges in diamonds, which not exposed to radiation are perfect insulators at room temperature. Diamond technology is still far behind silicon technology, since we have been working with silicon for around seventy years and our adventure with diamonds started just a couple of decades ago. However, it's developing fast.

Are all diamonds suitable, or do you only use synthetic diamonds?

The distinction between synthetic and natural diamonds seems rather, well, artificial to me. The diamonds we use are synthetic in that they are man-made, but they are no different to those extracted from mines. If anything, they are generally even purer.

In any case, we are interested in controlled impurities. For diamonds to be suitable in electronics, they need to have semiconductor properties. Pure diamond doesn't meet this condition; it's only by adding other elements to increase the number of electrons or holes that makes it a semiconductor. Boron atoms are one common additive.

You are currently working on diamond-based membranes.

That's right. I am developing membrane detectors which include a diamond layer a few microns thick to detect ionizing radiation.

What will they be used for?

One application is monitoring of low-energy radiation beams at modern light sources, for instance synchro-

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trons. The French SOLEIL synchrotron uses 30 of our diamond detectors in daily measurements; additionally it is planned that each detection line will be fitted with diamond beam monitors. The accuracy of our detectors is far higher than existing devices.

Synchrotrons are circular particle accelerators in which particles are accelerated in a magnetic field generated synchronously in resonator apertures while they are circulating in the magnetic field. The accelerated particles emit synchrotron radiation. In the SOLEIL synchrotron, the energy reaches around 100 keV. Different radiation energies have different applications. For example, they can be used to measure material properties or protein structures. Other radiation beams have industrial applications, for example in tomography of jet engines, or in radiobiology where live cells are irradiated.

The beam needs to be directed to the samples. Our diamond detectors are placed directly in-beam to provide real-time information on its quality (precise position and intensity), helping us perfect the experiments.

Such research isn't conducted singlehandedly, is it?
We collaborate closely with several international teams. Diamond membranes are studied by three groups: the team at my laboratory, a team at two institutes in Japan, and a group in Zagreb in Croatia which focuses on microbeams. When they needed diagnostic equipment, it turned out that diamond technology may be useful, which marked the beginning of our collaboration. The team at the PAS Institute of Nuclear Physics in Kraków works on diamond detectors with applications in proton therapy and beam diagnostics.

Has your research resulted in new patents?
I am the co-author of two patents using diamonds in radiation detection. One concerns diamonds in radiotherapy dosimetry, while the other focuses on silicon-diamond composites. We have built silicon diodes with a nanolayer of boron doped diamond, to measure and identify radioactive elements emitting alpha particles in water. This allows us to determine if water is contaminated with specific radioactive elements.

What do you do about publishing results when applying for patents? Can you discuss some findings, but not all?
Until you have filed a patent application, it's best not to discuss anything.

Interview by
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