New process holds promise for synthetic diamond crystals

Synthetic diamond crystals have unique properties that make them well suited for applications such as lenses for high-energy laser optics, x-ray radiation detectors, and ophthalmological scalpels. Scientists at the Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg, Germany, are now manufacturing high-quality artificial diamonds in all shapes and sizes.

Researchers are able to produce 3D geometries and discs of different diameters and thicknesses by using plasma-enhanced chemical vapor deposition (CVD), a process by which diamond is chemically deposited on a substrate from the gas phase. A specially pretreated silicon or silicon dioxide (silica) substrate is coated with diamond by means of microwave plasma in an ellipsoidal reactor. Fraunhofer IAF’s diamond lab contains eight such plasma reactors for growing diamonds in both polycrystalline and single-crystal form. Scientists can determine the orientation of polycrystalline diamond growth by applying small diamond seed crystals to the substrate before plasma deposition occurs. Single-crystalline diamonds with a continuous homogenous crystal lattice structure, however, must be grown on a single-crystal diamond substrate.

“We use CVD because it allows us to coat larger substrates, unlike other manufacturing processes such as the high pressure, high temperature method. What’s more, this method will enable us to produce diamonds of high enough quality for use in electronic applications, and means we can homogeneously deposit diamonds with diameters to 10 cm on silicon substrates,” explains group manager Nicola Heidrich.

Because diamond is chemically resistant, biocompatible, and able to withstand extreme temperatures, scientists are using it to develop electrochemical sensors that will be useful in the future. “The step from 33 to 38 tesla is significant. We will be able to clarify the properties of important materials to be uncovered and investigated. In a magnetic field of 38 tesla, certain quantum effects are 100 times stronger than in a field of 33 tesla, which, until now, was the maximum magnetic field available in the Radboud lab. In 2011, the HFML began an ambitious project of designing a resistive magnet that would surpass the current world record of 36 tesla.”

The High Field Magnet Laboratory (HFML) at Radboud University Nijmegen, the Netherlands, set a world record by generating a 38-tesla continuous magnetic field in a resistive (non-superconducting) magnet. The HFML design proves that expensive superconducting coils are not required to achieve 38 tesla, lowering purchasing costs tenfold.

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“The step from 33 to 38 tesla is significant. We will be able to clarify the properties of materials faster and more efficiently, and this will provide a major boost to materials innovation and development. Experiments in such high magnetic fields are currently only possible in the 45 tesla hybrid magnet, a partially superconducting magnet in Tallahassee, Florida, which is hugely overbooked and cannot satisfy all the demand. With the new magnet, we will make magnetic fields of this level available to a larger group of scientists,” says researcher Uli Zeitler.