Diamonds cutting environmental impact

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Diamonds are known as a girl's best friend due to their splendid sparkle, but they are also held in very high regard by industrialists, who prize their unmatched density, excellent thermal conduction and other properties.

Exploiting these unique properties is the key to a new kind of semiconductor that researchers hope could be a revolutionary advance in energy-efficient technology.

The artificial diamond super semiconductor is being developed by the Diamond Research Laboratory of the National Institute of Advanced Industrial Science and Technology (AIST) in Japan.

Artificial diamonds are most commonly produced by decomposing methane gas in a microwave oven at temperatures of about 1,000 Celsius. This process produces minute flakes of carbon, which pile up like accumulated snow to form a thin layer, or laminate, of diamond.

The AIST team has found a way to accelerate that process, and can efficiently produce diamond laminates measuring 2.3 centimeters square and 0.4 millimeter thick -- a size that ranks alongside the largest artificial diamonds produced.

While diamond has natural insulating qualities, adding minute amounts of boric acid and some other substances during the methane-decomposition process produces a diamond that also acts as an excellent semiconductor.

The resulting substance is described by the AIST team as "the ultimate insulator," far excelling silicon in terms of thermal radiation and voltage resistance. "Given that artificial diamonds can be produced from carbon, which is obtainable in abundance, the diamond semiconductors we envision would be well suited to mass production," said Shinichi Shikata, 56, who heads the AIST team. He joined AIST after quitting a managerial post with a diamond-processing company six years ago.

Shikata and his team foresee diamond semiconductors being used in electric vehicles and gas-electric hybrids.

Silicon semiconductors require a cooling system to prevent malfunction due to overheating. This is not true of diamond semiconductors, Shikata said, because of diamonds' heat-transfer efficiency.

The AIST team last year created a prototype semiconductor element measuring 1.6 centimeters square, incorporating a 3-square-millimeter diamond semiconductor.

If about 10 such elements were combined to form one large element, it would be suitable for use in the power control system of a hybrid vehicle, Shikata said.

A hybrid car equipped with such technology would consume about 960 kilowatt hours less per year than a conventional hybrid.

If every hybrid vehicle currently in use worldwide had such a system in place, their collective carbon dioxide emissions would be reduced by about 5 million tons over 40 years, he said.

"Our goal is for diamond elements to be in practical use within 10 to 15 years," he said. "If mass-produced, their production cost would be comparable to that of silicon-based elements."

"We'd like to see diamond semiconductors become commonplace some day, since they would be sure to help realize a low-carbon society," he said.

Shikata's laboratory also has been pursuing research into developing high-performance transistors with artificial diamonds.

By manipulating the elemental composition of the carbon flakes, the resulting artificial diamond's heat conductivity can be increased by 150 percent, and have the ability to latch on to electrons, Shikata said. "We can apply this phenomenon to the production of a high-performance transistor," he said.