Researchers create tiny magnetic diamonds on the nanoscale

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Diamonds have always been alluring, but now a team of scientists has made them truly magnetic -- on the nanoscale. In a paper published in the Aug. 26 issue of *Physical Review Letters*, the researchers report a technique to make magnetic diamond particles only 4-5 nanometers across. The tiny diamond magnets could find use in fields ranging from medicine to information technology.

Ferromagnetism has been historically reserved for metals, but scientists are becoming increasingly interested in the prospect of creating metal-free magnets, particularly from carbon-based materials. Diamond is a naturally occurring crystalline form of carbon.

Magnets made from carbon could have a number of advantages over their metal counterparts. "Carbon is lightweight, very stable, simple to process, and less expensive to produce," says Saikat Talapatra, a post-doctoral research associate with the Rensselaer Nanotechnology Center at Rensselaer Polytechnic Institute.

Talapatra is lead author of the study, which also included researchers from NASA Ames Research Center in California; Richmond, Va.-based Philip Morris USA; and the University at Albany.

"These findings could lead to a systematic, controllable method for producing magnetic carbon materials," says Pulickel Ajayan, the Henry Burlage Professor of Materials Science and Engineering at Rensselaer and co-author of the paper. "Though the value of the magnetization is much lower than in regular magnets, the nature of the spin interactions in carbon could lead to a number of potential applications."

Magnetic nanocarbons could make promising structures for high-density memory devices and in quantum computers. And because carbon materials are generally compatible with living tissue, these nanostructures could be useful in medical applications such as magnetic resonance imaging (MRI) and the targeted delivery of drugs to specific parts of the body.

Researchers have long known that defects and irregularities in pure carbon materials can give rise to electrons that are not paired with other electrons. Each "unpaired" electron produces a magnetic field by its spinning, and when all of the spins align, the material itself becomes magnetic. Talapatra and his colleagues have developed a way to modify the structure of carbon in a controlled manner by firing clusters of atoms at the diamond particles. This produces magnetism at room temperature, and the total strength of the magnetism depends on the amount and type of atoms used.

The next step, according to Talapatra, is to calculate how the types of defects and their concentration in the pure carbon structure affect the magnitude of magnetism. "We are also working toward developing simpler ways to make magnetic nanocarbons in a more controlled fashion," he says. "The long-term goal is to show some real applications using these structures."

Other Rensselaer researchers involved in the work were Robert Vajtai, laboratory manager for the Rensselaer Nanotechnology Center; Ganapathiraman Ramanath, associate professor of materials science and engineering; Mutsuhiro Shima, assistant professor of materials science and engineering; Gopal Ganesan Pethuraja, research engineer with the Center for Integrated Electronics; and Taegyun Kim, graduate student in materials science and engineering.

Source: Rensselaer Polytechnic Institute