A liberal sprinkling of quantum dots（图）

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Researchers at Rice University claim to have found a way to add electronic and optical elements to the "wonder material" graphene without sacrificing its mechanical properties. They have designed a technique for patterning the hydrogenated form of graphene with quantum dots – a phenomenon that promises many novel applications.

Graphene consists of 2D sheets of carbon just one atom thick arranged in a honeycombed lattice. Many scientists believe that the material could replace silicon as the electronic material of choice in the future thanks to its unique electronic and mechanical properties that would allow smaller devices to be made. Graphane is formed by simply adding hydrogen atoms to both sides of the graphene matrix. This material is an insulator, while graphene behaves like a metal.

Boris Yakobson and colleagues have found that removing hydrogen atoms from 2D sheets of graphane opens up tiny spaces in pure graphene that behave like quantum dots. Quantum dots are nanosized pieces of semiconductor in which electrons (or holes) are confined in 3D and their electronic properties can be controlled by changing the size of the dots. Quantum dots could be used to make nanoelectronic and optical circuits and devices, such as chemical sensors, solar cells and even semiconducting lasers, because they interact with light and magnetic fields in unique ways.

Phase transition

This phase transformation from graphene to graphane, accompanied by the change from metal to insulator, offers exciting opportunities for nanoengineers, says Yakobson. "If experimentally feasible, we can move from the labs to hopefully industrial tests and produce very small stable circuits and devices," he told physicsworld.com. He says that the new technique has clear advantages over existing methods to create graphene-based electronic devices such a cutting nanoribbons and then re-assembling them, which can be a very intricate procedure.

The researchers also discovered that when they removed pieces of the hydrogen sub-lattice, the area left behind tended to be hexagonal in shape with a sharp interface between the graphene and graphane. This means that each dot is self-contained and that little charge leaks across from the graphene quantum dots into the graphane host material. Although the Rice scientists do not yet know how to physically create arrays of quantum dots in sheets of graphane, they believe the obstacle "shouldn't be insurmountable".

Before this can happen though, the team says it needs to better understand distortions at the graphane-graphene interface and also if there is likely to be frustration there, disordered hydrogen atoms and possible roughness at the border lines. The researchers also need to find out whether the interface remains robust when placed on a support substrate, such as silicon.

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