Researcher explores the potential of graphene

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Research by Victoria University Professor Uli Zuelicke is contributing to the global race to unlock the potential of graphene, a new material taken from graphite that scientists say could be a game changer for new electronic applications.

Graphene is a sheet of carbon atoms that are arranged in a tightly bound hexagonal lattice. Tiny fragments of it are produced whenever graphite is worn away, such as when drawing a line with a pencil, and it has almost miraculous properties.

The atom-thick layer of graphene is the strongest material ever measured as well as the thinnest (three million sheets of graphene on top of each other would be just 1mm thick) and the stiffest. It is an exceptional conductor of heat and electricity and only absorbs around 2.3 percent of the light that passes through it, making it transparent.

Scientists first demonstrated that single layers of graphene could be isolated in 2004 and the discoverers were awarded the Nobel Prize for Physics in 2010.

The material has been touted as a possible replacement for silicon and a route to a host of faster, cheaper devices including the touchscreens of the future. A key advantage of making touchscreens from graphene is eliminating the need to use indium which is a rare metal in short supply.

"Graphene can be made from carbon," says Professor Zuelicke, "which is one of the most ubiquitous elements on earth."

But, he says, graphene's unique properties have so far largely been demonstrated on a small scale and much more needs to be known before it can be commercialised.

Professor Zuelicke's research area is understanding how electrons behave in solid materials such as semiconductors. He is currently investigating ways to mathematically model the properties of electrons in graphene with the ultimate goal of finding out how to predict and influence their motion.

"Individual electrons, which are mobile and carry the current through a semiconductor, have counterintuitive properties that allow them to move through a matrix of atoms without ever bumping into them. They appear to be free even though they are contained in this tight web of atoms.

"The price they pay is that their mass is changed by this process. Within the range of different types and combinations of atoms, a huge number of complex, new structures are possible. That opens the door to a vast range of new materials each of which is like a new universe in terms of how the electrons behave."

In graphene, says Professor Zuelicke, the change in the way electrons behave is dramatic and unlike what has been observed in any other material.

"They can't speed up or slow down or easily change direction. In that, they have the same properties as particles (neutrinos) that move at the speed of light but the constant velocity of the electrons in graphene is only about 1/300th of the speed of light. Basically, the behaviour of electrons in graphene realises a slow version of relativity."

Professor Zuelicke says these properties allow scientists to observe and find out more about Einstein's theory of relativity in a novel setting.

"To test our understanding of relativity, we usually have to accelerate electrons to bring them closer to the speed of light but the much slower electrons in graphene already behave like their fast-moving cousins in accelerators. They are an almost ideal test bed for interesting quasi-relativistic effects."

Working with collaborators in the United States, Professor Zuelicke has nearly completed four years of Marsden-funded research and intends to continue with the theoretical work and the practical applications of the research.

"Internationally, there is huge effort focused on ways of making graphene and understanding what we can do with it."

He says stacking layers of graphene on top of each other or varying the size, composition or layout of the sheet of material can create a multitude of new properties.

"Our research today is the ground work to come up with a new paradigm of electronics."

Provided by Victoria University

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