Creating Nanoscale Devices

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Creating the next generation of electronic devices—be they computers, smartphones or displays—will depend on understanding the properties of materials on the nanoscale—one-billionth of a meter.

Aron Pinczuk's research projects employ advanced optics methods in condensed-matter science, with a focus on understanding the properties of novel materials and the physics of exotic states of matter that emerge in semiconductors at extremely low temperatures. His research findings address issues used by scientists seeking the development of quantum computing and cryptology. The research on graphene, a single atomic layer of graphite, contributes to the quest to initiate a new era in the creation of electronic components.

Pinczuk conducts his research at the Nanoscale Science and Engineering Center at Columbia, in the Department of Applied Physics and Applied Mathematics, and in the Department of Physics. His laboratory had support from the Keck Foundation and his research is funded through the National Science Foundation, the Department of Energy, and the U.S. Office of Naval Research, which support projects that span disciplines in science and engineering.

His research has explored the properties of gallium arsenide, a semiconductor, which is used in advanced optoelectronics, lasers, microwave circuits, and solar cells. To determine material properties in condensed matter systems, he subjects gallium arsenide to temperatures below 0.1 Kelvin, a temperature at which almost everything freezes. At these temperatures, the electrons cool down to make a liquid, emit light, and exhibit new, unexpected behaviors.

His research with gallium arsenide also has added to the basic science needed to develop a quantum computer, in which computational operations are executed in quantum bits. Theoretical studies show that quantum computers can solve certain problems quicker than classic, digital computer systems.

His findings also have assisted those looking to develop ways to use complex quantum states to build a key used to encrypt computer information. Such encrypted keys could be used to improve the security of computer systems.

Pinczuk's research with the carbon material, graphene, is part of the effort to develop a new generation of electronics that use carbon components. He studies the properties of carriers of an electric charge as it travels through a single layer of graphene, which is two-dimensional. Scientists are working on larger scale integration of these layers, which will create multi-layer structures with new properties.

"In the case of graphene, there are new properties that develop when you put all the layers together," said Pinczuk. "It's a field that is rapidly evolving."

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