Researcher Uses Graphene Quilts to Keep Things Cool

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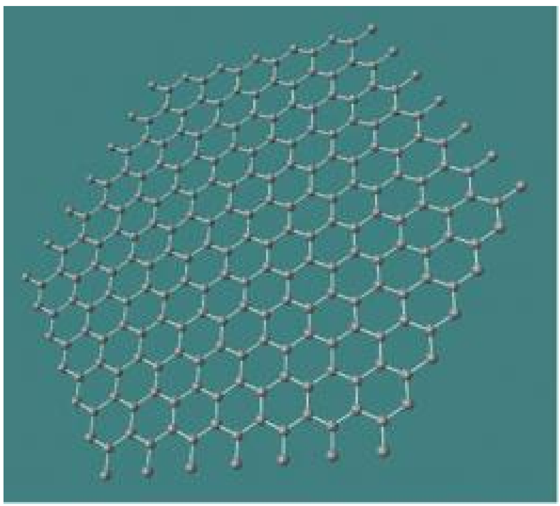

Graphene

(PhysOrg.com) -- University of California, Riverside Professor of Electrical Engineering and Chair of Materials Science and Engineering Alexander Balandin is leading several projects to explore ways to use the unique capabilities of graphene ?quilts? as heat conductors in high-power electronics.

University of California, Riverside (UCR) Professor of Electrical Engineering and Chair of Materials Science and Engineering Alexander Balandin is leading several projects to explore ways to use the unique capabilities of graphene “quilts” as heat conductors in high-power electronics.

Graphene is a recently discovered single-atom-thick carbon crystal, which reveals many unique properties. In Balandin's designs, graphene "quilts" (large-area overlapping networks of graphene flakes) will play quite an opposite role of your grandma's quilts. They will remove heat instead of retaining it.

His work on graphene heat-conducting coats for heat removal from high-power gallium-nitride transistors is being funded by a recently awarded $420,000 grant from U.S. Office of Naval Research (ONR). It aims at an experimental proof-of-concept demonstration to be conducted in Balandin's Nano-Device Laboratory (NDL).

In addition to the ONR grant, Balandin received a new three-year subcontract with the Interconnect Focus Center (IFC), based at the Georgia Institute of Technology, that deals with graphene interconnects and heat spreaders for three-dimensional (3-D) electronics. According to the International Technology Roadmap for Semiconductors, in the next five years, up to 80 percent of microprocessor power will be consumed by the interconnect wiring—a driver for the search for new interconnect materials and innovative methods of heat removal.

Another recent subcontract awarded to Balandin is with the Functional Engineered Nano Architectonics (FENA) center based at UCLA. In this center, he investigates the problems of energy dissipation in graphene nanostructures and nanodevices. Combined new funding secured by Balandin this month for the three projects exceeds $1 million. The centers' funding comes from the Semiconductor Research Corporation (SRC) and Defense Advanced Research Project Agency (DARPA).

Most of the current research on graphene has focused on its electronic properties and graphene's potential for high-speed nano-circuits. Due to its unique structure, electrons travel at extremely high speeds throughout it.

Balandin is focusing on another of graphene's remarkable properties: it's extraordinarily high thermal conductivity, which can be used for heat removal in nanoscale and 3-D electronics. The higher speed, higher power densities and increased thermal residence in the state-of-the-art devices result in development of hot spots, performance degradation and thermal breakdown. Balandin's proposed graphene-based approach for thermal management represents a radical departure from conventional methods and might lead to creation of a new technology for hot-spot spreading.

Because graphene is only one molecule thick, it didn't lend itself to traditional methods of thermal conductivity measurement. Balandin led a team of researchers that first measured it using an original non-conventional technique in 2008. The procedure involved a non-contact approach on the basis of Raman spectroscopy utilizing the inelastic scattering of photons (light) by phonons (crystal vibrations). The power dissipated in graphene and corresponding temperature rise were detected by extremely small shifts in the wavelength of the light scattered from graphene. That was sufficient to extract the values of the thermal conductivity through an elaborate mathematical procedure.

Balandin's research group discovered that the thermal conductivity of large suspended graphene sheets varies in the range from about 3000 to 5300 W/mK (watts per meter per degree Kelvin) near room temperature. These are very high values, which exceed those of carbon nanotubes (3,000-3,500 W/mK) and diamond (1,000-2,200 W/mK).

As a result of his findings, Balandin has proposed several innovative graphene-based approaches for thermal management , which might lead to creation of a new technology for local cooling and hot-spot spreading in the high-power-density and ultra-fast chips. A detailed description of Balandin's graphene and thermal management research can be found in his invited popular science article, "Chill Out," in the October 2009 issue of *IEEE Spectrum*, the magazine of the The Institute of Electrical and Electronic Engineers (IEEE).

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