Could Graphene Replace Semiconductors?

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(PhysOrg.com) -- “People want a faster computer chip,” Philip Kim tells *PhysOrg.com*. “And it needs to be smaller. But in order to increase the speed of the chip, or to get it smaller, we are approaching a point where you need materials other than silicon.”

Kim, professor at Columbia University, believes that graphene may be just that material. Along with his colleagues, Bolotin, Sikes, Hone and Stormer, Kim thinks that suspended graphene may provide the transport capability needed to reach greater speeds in computer ships. The work of the group from Columbia University can be found in *Physical Review Letters*: “Temperature-Dependent Transport in Suspended Graphene.”

When one looks at the structure of graphite, stacked layers of pure carbon are apparent. However, it wasn’t until 2004 that a process sophisticated enough to “slice” off one of the layers was discovered. This single layer is called graphene. Graphene is basically a sheet of bonded carbon atoms, with the thickness of only one atom. If one could look down at graphene from the top, one would observe that the sheet bears a strong resemblance to honeycomb, with its hexagons fitted snugly together.

“Graphene behaves almost like semiconductor but without a energy gap,” Kim explains. This is why it would do well as a material for computer chips. “When you apply an electric field perpendicular to graphene, the number of electrons – the carrier density – can be tuned.”

“One of the main themes is how fast the charge can move in graphene,” Kim continues. “Higher mobility means electron conducts faster in the system. It has always been speculated that the mobility of graphene can be quite high. But it has not been shown as high as some of the highest semiconductors in the past.”

The group at Columbia University, however, has shown that graphene can exceed the transport speed of even the semiconductors with the highest mobility. They have done this by suspending the graphene at room temperature. “We have found that this transport ability is higher in the graphene than in any known semiconductor at room temperature.”

“Lower mobility in graphene comes from external impurities, rather than intrinsic limitations,” Kim explains. “So the question becomes how to remove these impurities. Many of the impurities actually come from the substrate; this is the substance the graphene is sitting on. Suspending the graphene and subsequently annealing it would help ‘clean’ the graphene, and increase the mobility.”

The current work also shows that temperature plays a role in the transport ability of graphene. “We found that the graphene has the highest mobility at room temperature,” Kim says. “This is great, since various applications would get more use out of something that can work in the real world.”

And the future? Kim believes that there are still impurities in the graphene. “There are still limits right now,” he says. “I think we can bring the mobility even higher.”

Kim maintains that this discovery of temperature-dependent transport in graphene goes beyond practical application. “Every time you discover something like this – where mobility is really enhanced – it results in a discovery of new physics. I think the same thing will happen with graphene. Improving mobility will allow us to look at new physics in a very exotic system.”