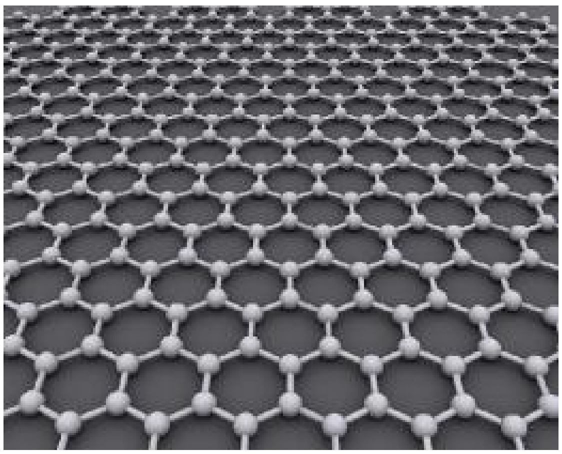
Graphene found to emit infrared light

April 26 2012, by Bob Yirka



Made of a single sheet of carbon atoms, graphene can be spun at the fastest rate of any known macroscopic object. Image credit: Wikimedia Commons.

(Phys.org) -- Ever since its discovery in 2004, graphene, the honey-comb arranged sheet of one atom thick carbon atoms, has continued to make waves in both the physics and engineering worlds. Now comes news from yet another research team heralding a new found property of the fascinating material. This time, as the group describe in their paper published in *Physical Review Letters*, it’s been found to have optical gain properties as a result of population inversion of electrons when struck with a short blast from a laser.

Optical gain means that if light is shined onto a material, it reflects back more than was sent in; a very useful property for making optoelectric devices such as lasers, amplifiers, modulators and absorbers.

In this latest research effort, the team used graphene that had been epitaxially grown, which is where a crystalline substance is overlaid onto a substrate, resulting in a sheet of high quality graphene. They then excited the graphene with pump laser (1.55 eV.) pulses of very short duration (35 fs). In measuring the amount of light that was reflected back, they found it was more than was sent in. This they say, was because of graphen's unique physical properties which causes it's light conduction to change from positive to negative, which of course means that it reflects more than it absorbs.

More specifically, the material's optical gain property occurs because as the pump laser pulse strikes the graphene, its electrons become excited with more charge carriers winding up in the Dirac cone than in the lower cone (population inversion). Because of the imbalance, a probe photon stimulating the excited states causes the emission of infrared light. And what's more, the gain is more than that for conventional optical devices. Additional research by the team showed that the optical gain observed with the graphene sample could occur over a wide range of energy pulses from the laser as well, leading to even more potential applications.

While their research is promising, the team acknowledge that much more work needs to be done before any actual real world devices could be created that take advantage of this new-found property of graphene, but eventually, the hope is that such equipment will be able to carry out their tasks faster than what is currently available, allowing for the development of high-speed telecommunications devices capable of keeping up with the ever growing demand for faster networks.

More information: Femtosecond Population Inversion and Stimulated Emission of Dense Dirac Fermions in Graphene, *Phys. Rev. Lett.* 108, 167401 (2012) DOI:10.1103/PhysRevLett.108.167401

Abstract

We show that strongly photoexcited graphene monolayers with 35 fs pulses quasi-instantaneously build up a broadband, inverted Dirac fermion population. Optical gain emerges and directly manifests itself via a negative conductivity at the near-infrared region for the first 200 fs, where stimulated emission completely compensates absorption loss in the graphene layer. Our experiment-theory comparison with two distinct electron and hole chemical potentials reproduce absorption saturation and gain at 40 fs, revealing, particularly, the evolution of the transient state from a hot classical gas to a dense quantum fluid with increasing the photoexcitation.