Graphene offers protection from intense laser pulses

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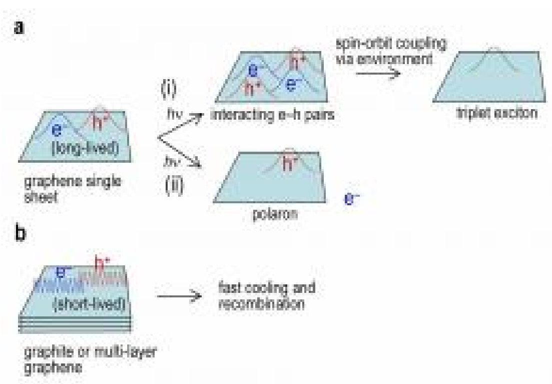

The new optical-induced absorption mechanisms [a] Photoexcitation of a dispersed graphene single sheet gives long-lived electron-hole pairs. Further excitation causes the appearance of localized states such as (i) excitons (neutral excited state) or (ii) polarons (charged excited state) due to interactions. [b] For comparison, graphite gives on electron-hole gas that is very short-lived due to fast cooling and re-combination. Credit: National University of Singapore

Researchers from Singapore and the UK have jointly announced a new benchmark in broadband, non-linear optical-limiting behavior using single-sheet graphene dispersions in a variety of heavy-atom solvents and film matrices.

Single-sheet graphene dispersion when substantially spaced apart in liquid cells or solid film matrices can exhibit novel excited state absorption mechanism that can provide highly effective broadband optical limiting well below the onset of microbubble or microplasma formation.

Graphenes are single sheets of carbon atoms bonded into a hexagonal array. In nature, they tend to stack to give graphite.

In a breakthrough, researchers from the National University of Singapore (NUS), DSO National Laboratories and University of Cambridge have developed a method to prevent the re-stacking of these sheets by attaching alkyl surface chains to them, while retaining the integrity of the nano-graphene pockets on the sheets.

This method in turn produced a material that can be processed in a solution and dispersible into solvents and film matrices. As a consequence, the researchers observed a new phenomenon. They found that the dispersed graphenes exhibit a giant non-linear optical-absorption response to intense nanosecond laser pulses over a wide spectral range with a threshold that was much lower than that found in carbon black suspensions and carbon nanotubes suspensions. This set a new record in energy limiting onset of 10 mJ/cm^2 for a linear transmittance of 70%.

The mechanism for this new phenomenon is outlined in Figure 1 in which the initially delocalized electron-hole gas localizes at high-excitation densities in the presence of heavy atoms, to produce strong absorbing excitons. The resultant excited-state absorption mechanism can be very effective.

These optical limiting materials can now be used for protection of sensitive sensors and devices from laser damage, and for optical circuits. They can be also used in anti-glare treated devices.

The principal investigator of the NUS Organic Nano Device Laboratory's graphene team, Professor Lay-Lay Chua who is also from the NUS Department of Chemistry and Department of Physics, says: "We found from ultrafast spectroscopy measurements that dispersed graphene sheets switch their behavior from induced optical transparency which is well-known, to induced optical absorption depending on its environment. This is a remarkable finding that shows graphene can still surprise!"

The principal investigator of the graphene team at DSO National Laboratories, Professor Geok-Kieng Lim who is also an Adjunct Professor at NUS Department of Physics, says: "This is an important first step in the development of practical graphene nano-composite films for applications where the graphene sheets remain fully dispersed. The induced change in their non-linear optical behavior is amazing and highly practical."

More information: 'Giant broadband nonlinear optical absorption response in dispersed graphene single sheets' by Geok-Kieng Lim, Zhi-Li Chen, Jenny Clark, Roland G.S. Goh, Wee-Hao Ng, Hong-Wee Tan, Richard H. Friend, Peter K. H. Ho and Lay-Lay Chua was published on 21 August 2011 in *Nature Photonics* and is available at www.nature.com/nphoton (doi:10.1038/nphoton.2011.177).

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