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JOINT DEVELOPMENT OPPORTUNITY

Gate-Tunable Large-Scale Graphene as Saturable Absorber using Ferroelectric Polymer Gating

This invention refers to a saturable absorber device for use in a laser cavity. It comprises an optical element, e.g. optical fibre, glass substrate, mirror, that supports a saturable absorber material, which in itself has a polarized ferroelectric material and a graphene substrate. This graphene substrate is layered with the ferroelectric material to form a gate-tunable graphene-ferroelectric hybrid saturable absorber.

Illustration 1

Figure 1

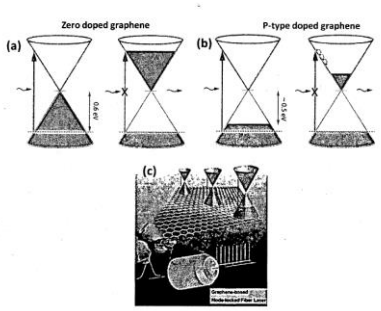

Figure 2

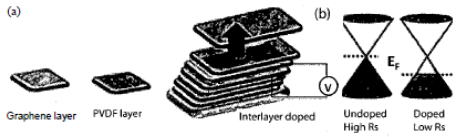

Fig 1: Working principle of graphene-based saturable absorber, showing the excitation process in (a) pristine graphene and (b) heavily p-type doped graphene; Fig 2: (a) Stack of graphene-ferroelectric PVDF layers; (b) band structures of undoped and doped graphene

Illustration 2

Figure 3

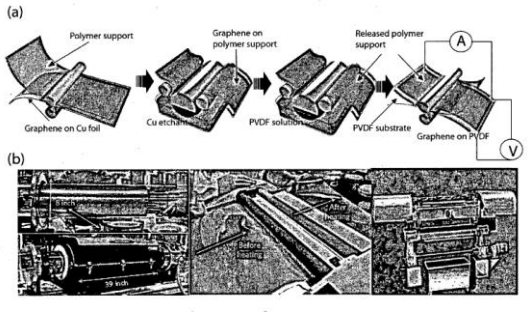

Figure 4

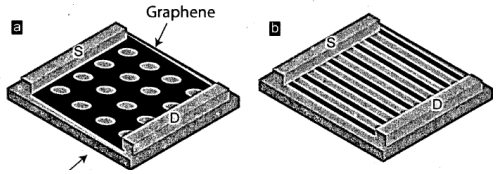

Fig 3: Roll-to-roll fabrication of layered graphene-PVDF saturable absorber material; Fig 4: Graphene substrate patterned in a micro-shape structure comprising a circularly array, a micro-ribbon array, or a combination thereof.

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Technology Background

A saturable absorber is a critical optical component in ultrafast lasers (devices which produce a train of short pulses of light of less than a picosecond in duration) with a certain optical loss, which is reduced at high light intensity. The main application of a saturable absorber is in the mode locking and Q-switching of lasers, i.e., the generation of short pulses. However, they are also useful in in the processing of optical signals. The current dominant technology, using semiconductor saturable absorber mirrors (SESAMS), suffers from narrow tuning ranges and complex fabrication and packaging. A simple cost effective solution that has been proposed is based on single-wall carbon nanotubes (SWCNTs). While the advantages of this solution are attractive, the absorber's properties are not precisely controllable. Under certain conditions, the SWCNTs may also operate with some insertion losses (loss of signal power due to the introduction of a device in the transmission line).

Application Areas

- Plasmonics, e.g. gate tunable plasmonics in THz metamaterials which have practical usage in optical waveguides, biosensors and creating high resolution optical images;
- Fibre lasers, ultrafast lasers, light detectors for optical signal processing, mode locking, Q-switching, optical pulse shaping, optical switching.

Benefits Offered

- **Ultrafast recovery time for generating ultra-short energetic pulses**;
- Cheap fabrication, low power consumption and multi-wavelength operations
- **Low power intensity inputs**;
- **Multi-wavelength operation or wideband tunability**;
- **Tunable wavelengths** for individual laser pulse;
- **Flexibility of saturable absorber materials** : (a) *graphene substrate*, including - graphene sheet, activated reduced graphene oxide, graphene flake or a combination thereof; (b) *ferroelectric material (polymer or copolymer)* that includes vinylidene fluoride, trifluoroethylene, 11-aminoundecanoic acid, thiourea or a combination thereof; (c) *ferroelectric material (ceramic material)* comprising bismuth ferrite, barium titanate, lead titanate, sodium nitrite and potassium phosphate or a combination thereof.

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