Optical properties and applications of graphene and graphene-based structures

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Recall that graphene is a two-dimensional structure where the carbon atoms are arranged in hexagons. Graphene is a constituent unit of graphite and it has been used as a theoretical model to describe other forms of carbon allotropes, such as fullerenes and nanotubes. Despite the fact that the first experimental samples of graphene have been obtained recently (in 2004), there is already a lot of studies on graphene applications in various areas. The number of publications devoted to graphene grows exponentially as a function of time.

All of the features of graphene are based on its band structure. In the first Brillouin zone of graphene, there are special points K and K', near those the dispersion of the electron energy has a linear dependence on the wave vector. Thus, graphene is a semiconductor with a zero band gap and the beh aviour of the electrons is described not by the Schrödinger equation (as in bulk semiconductors), but by a two-dimensional Dirac equation for massless quasi-particles. Due to its specific electronic structure graphene demonstrates unique electronic properties, such as quantum Hall effect, ultra-high electron mobility, etc. Moreover graphene has outstanding optical performance. Its optical absorption, equals to 2.3% of the incident radiation intensity, does not depend on wavelength.

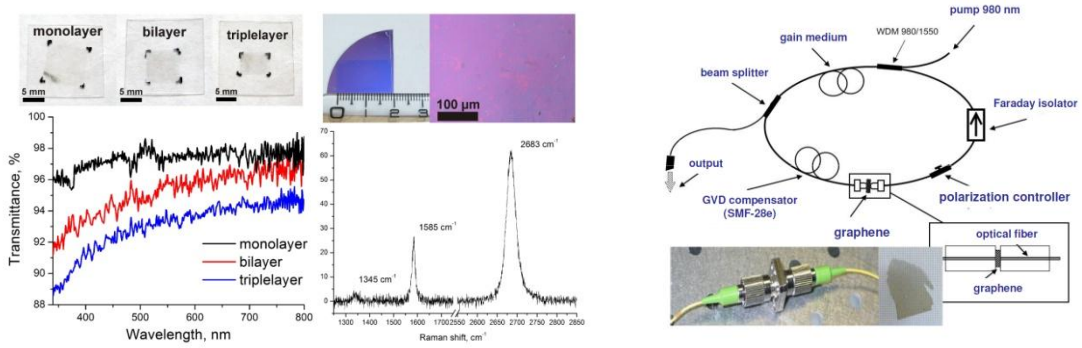

Fig. 1. Photographs of graphene on glass and Si/Sio_2 substrate and its optical absorption spectra and Raman spectrum (left). Scheme of mode-locked laser with graphene saturable absorber (right).

In this work we present a full cycle of graphene investigation from synthesis to applications [1-6]. At first, the installation for the synthesis of graphene was created and linear and non-linear optical properties of synthesized graphene were studied. Then the model of hybrid structure based on graphene and photonic crystal was studied using computer methods and the samples with desired properties were produced. Moreover, we present the results on graphene application as non-linear element for mode-locked lasers.

Finally, in this work a very recent results on graphene doping by different impurities for tailoring optical properties of graphene are demonstrated.

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