CVD graphene transfer: Alcohol/water solvent for improved removal of PMMA with polarity modified under DUV exposure

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1. Two-stage removal of PMMA supportive layer for the CVD graphene transfer.

We demonstrate the development of a simple, environmentally-friendly technique to remove the poly(methyl methacrylate) (PMMA) layer from graphene, synthesized by a chemical vapor deposition (CVD), on different substrates.

As the first step, the polarity of the PMMA was modified under the influence of deep-UV irradiation as a result of its photodegradation, namely scissions of main-chain, as well as side chains of the polymer [1]. Since the DUV intensity is lower than that of an e-beam or X-ray radiation, this avoids destructive crosslinking under DUV exposure. Moreover, the main-chain scission products have time to absorb photons and contribute to polymer degradation due to side-chain scission too. As a result, stable products are formed, including ketone-type and aldehyde-type carbonyl compounds, which have a higher polarity than pristine PMMA. The modification of PMMA polarity was confirmed by UV and FTIR spectrometry and the contact angle measurements (see Fig.1).

Consecutive dissolution of a polarity modified polymer in a binary mixture of isopropyl alcohol/water (more commonly alcohol/water), prepared in a certain proportion (see Fig.2), results in rapid and complete removal of PMMA without degradation of graphene properties. The mechanism is that when the number of water and IPA molecules is equal, they begin to form water-alcohol hydrogen bonds, destroying existing intermolecular clusters with hydrogen-bonds (water-water and IPA-IPA), and thus simplifying access to the surface of the soluble substance.

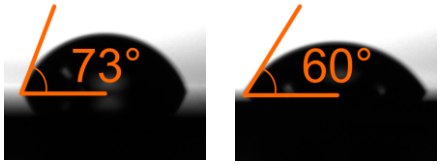

Fig.1 **Polarity of PMMA pristine (left) and after deep-UV exposure (right)**

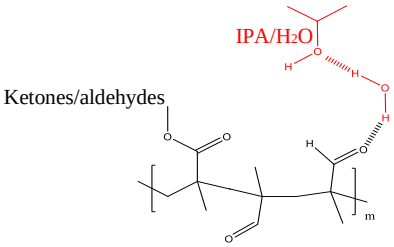

Fig.2 **Dissolution of modified PMMA with aqueous isopropyl alcohol**

The high quality of graphene after PMMA removal was confirmed by Raman spectrometry. For comparison, PMMA removal from graphene was also performed by the most common methods. The electrical properties of graphene films were investigated using THz time-domain and infrared spectroscopy methods, which, being contactless, are perspective for characterization of CVD graphene in commercial applications [2]. The mobility has reached 6900 $cm^2/(V \cdot s)$, which makes the proposed PMMA removal method promising for use in the fabrication of high-performance large-scale graphene-based electronic devices [3].

2. Acknowledgement.

Work was supported from the Research Council of Lithuania (Lietuvos mokslo taryba) through project “Hybrid plasmonic components for THz range (T-HP)” under Grant No. 01.2.2-LMT-K-718-03-0096 (DOTSUT-184).

3. References

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