AN ALTERNATIVE SUBSTRATE FOR THE INVESTIGATION OF TWO-DIMENSIONAL MATERIALS

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Abstract

Since the discovery of two-dimensional materials, there is a strong research focus motivated by their unique properties. Such investigations give a way to several applications and discoveries not observed in the 2D bulk counterparts. However, practically all research in 2D materials until now was performed with Si/SiO_2 as the substrate and 2D material support by default. This research focuses on the possibility of using HOPG as a universal substrate for the future investigation of two-dimensional materials due to a number of unique properties such as chemical purity, stability, high flatness, and electrical conductivity. This study demonstrates the results of a systematic investigation with AFM, photoluminescence, and Raman spectroscopy of 2D materials deposited on HOPG and several other substrates. The obtained results show a strong interaction between HOPG and two-dimensional materials. The enhanced adhesion to HOPG allowed the instant deposition of different kinds of 2D materials that is normally not easily accomplished on SiO_2. This work shows the advantages and potential of an alternative substrate that could make a significant impact in future investigation of novel 2D materials.

Introduction

Since the first isolation of single layer graphene in 2004 and the recognition of this research with the award of a Nobel Prize in 2010, the number of new two-dimensional materials has grown significantly. Nowadays, there is a strong research focus on two-dimensional materials motivated by their unique properties that arise when van der Waals materials are scaled down to the single or few layers level [1]. Such physical properties are usually not observed in their 3D counterparts. These properties make them promising materials for different applications and pave the way to the future discoveries involving physical systems spatially confined in 2D. However, practically all research in 2D materials until now has been performed with SiO_2/Si as the substrate and 2D material support by default. A systematic investigation of other materials as support for 2D layers is nowadays missing in the literature. Such investigation could give a way to alternative substrates with better adhesion and chemical inertness allowing a next wave of discoveries in this hot topic of layered van der Waals materials.

In the present study we demonstrate that graphite offers significant advantages with respect to the usual SiO_2/Si substrate due to the number of unique properties. The chemical purity and stability of the substrate, the high flatness and good conductivity properties, the possibility to deposit any kind of 2D material from multilayer to monolayers makes graphite a good choice as an alternative substrate.

Materials and Methods

In this study, we present the results of a systematic investigation with atomic force microscopy (AFM), current sensing AFM (CSAFM), Kelvin probe force microscopy (KPFM), photoluminescence (PL), and Raman micro-spectroscopies of GaSe, MoS_2, and $ZnIn_2S_4$ deposited by mechanical exfoliation on several other substrates (SiO_2, indium tin oxide, mica) and HOPG.

Results

The obtained results demonstrate a strong interaction between HOPG and two-dimensional materials. The close contact between the 2D layer and graphite, readily achieved without the need of external pressure, is reflected by the direct propagation of native defects in the substrate all the way up to the top layers of the deposited 2D layer (Fig.1). We attribute this large interaction to graphite as due to van der Waals interactions

between the two layered materials. The conductive nature of HOPG allowed the investigation of the transport and electronic properties of different 2D materials at the nanoscale by CSAFM and KPFM. The enhanced adhesion to HOPG allowed the instant deposition of different kinds of 2D materials that is normally not easily accomplished on SiO_2. The Raman and photoluminescence spectroscopy investigations show that the pristine properties of the 2D materials are preserved despite the remarkable vdW coupling to HOPG.

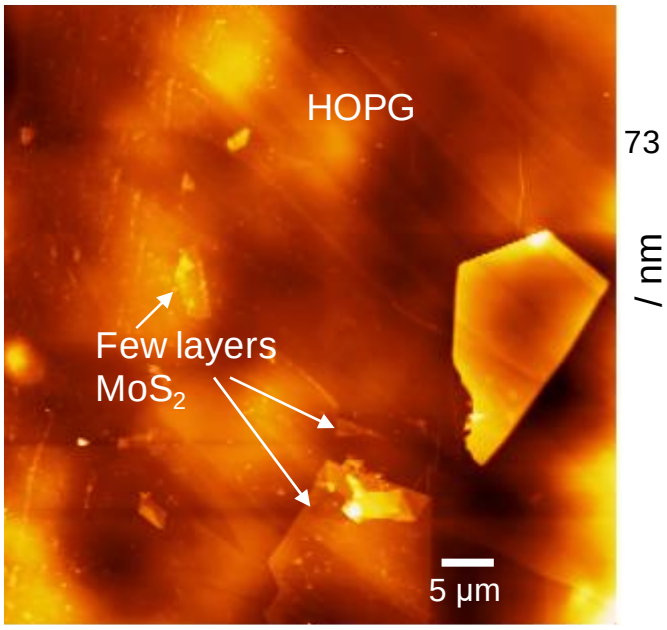

Fig.1 AFM of MoS_2 on HOPG

Conclusions

Graphite shows its potential as a good alternative to the usual SiO_2/Si substrates due to a number of unique properties such as chemical purity, stability, high flatness and strong interactions with 2D materials. The obtained results make a significant impact in the future research of novel two-dimensional materials. Our research also paves the way to the investigation of 2D materials with low chemical stability (*i.e.*: phosphorene, silicene, and others not yet reported) which should benefit from a substrate with a large non-covalent interaction.

Reference

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