Raman characterization and manipulation of graphene layer to create field-effect transistors

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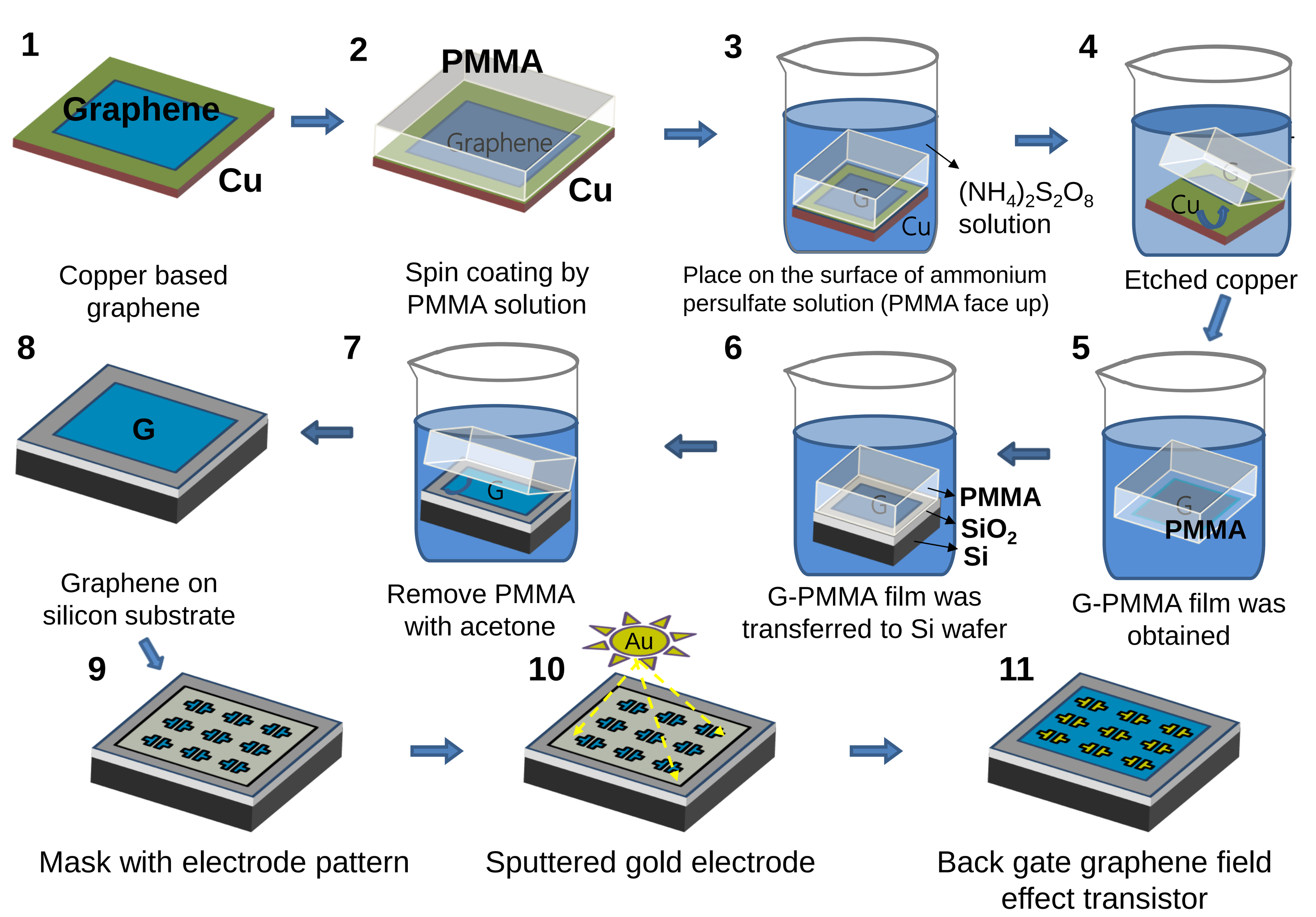
NANO 2021

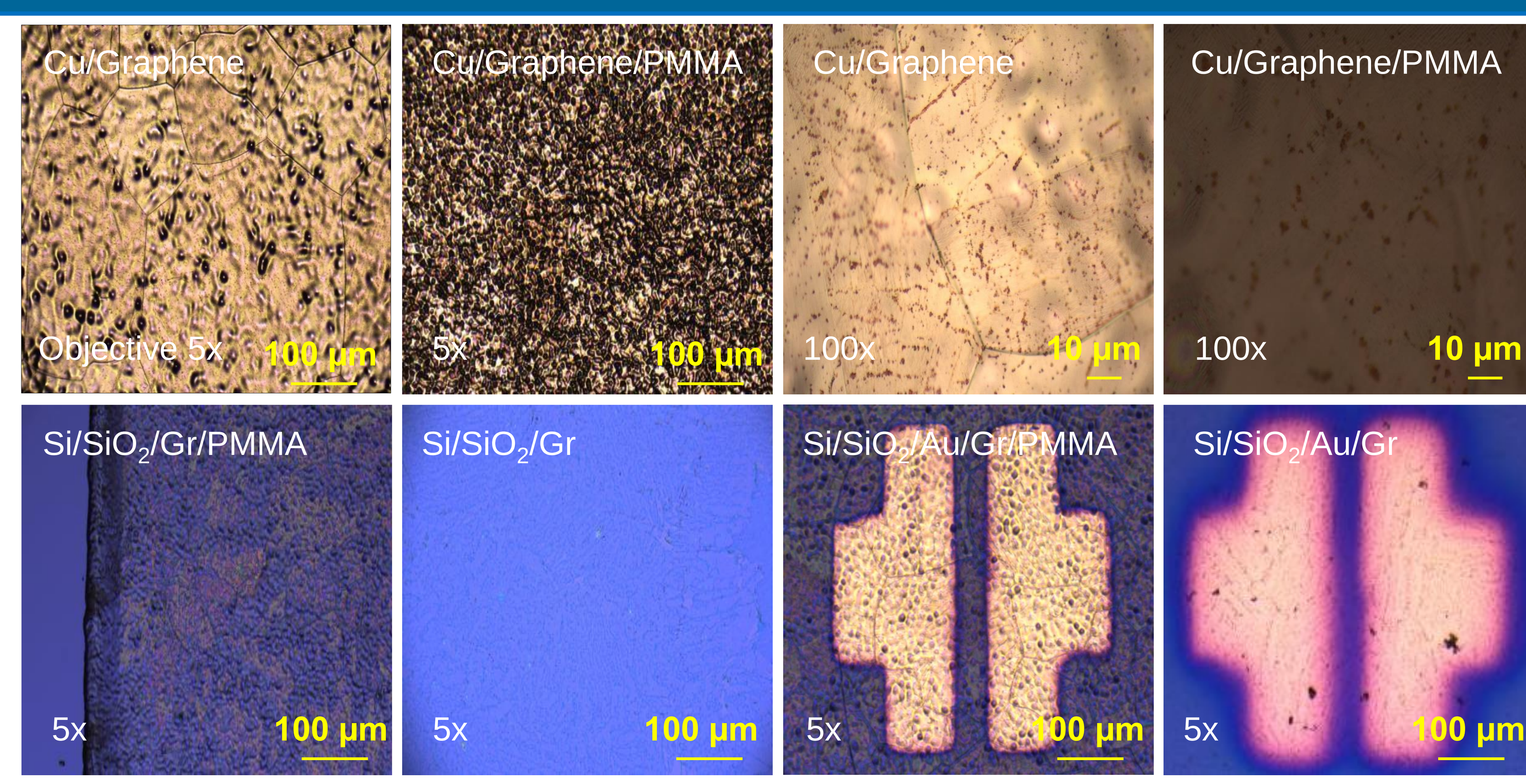
INTRODUCTION

Graphene is a two-dimensional (2D) material consisting of a flat monolayer or several layers of carbon atoms arranged in a honeycomb lattice structure. The 2D nature of graphene infers a number of interesting properties. The charge carriers satisfy Dirac's equation in quantum mechanics and are known as massless Dirac Fermions. This unique situation arises due to interactions with the periodic potential of the honeycomb lattice. These massless Dirac Fermions can be considered as electrons that have lost their rest mass. This in combination with other novel effects such as the room temperature quantum Hall effect, high thermal conductivity, and tunable band gaps makes graphene potentially useful for innovative approaches to electronic devices and other applications.

PREPARATION



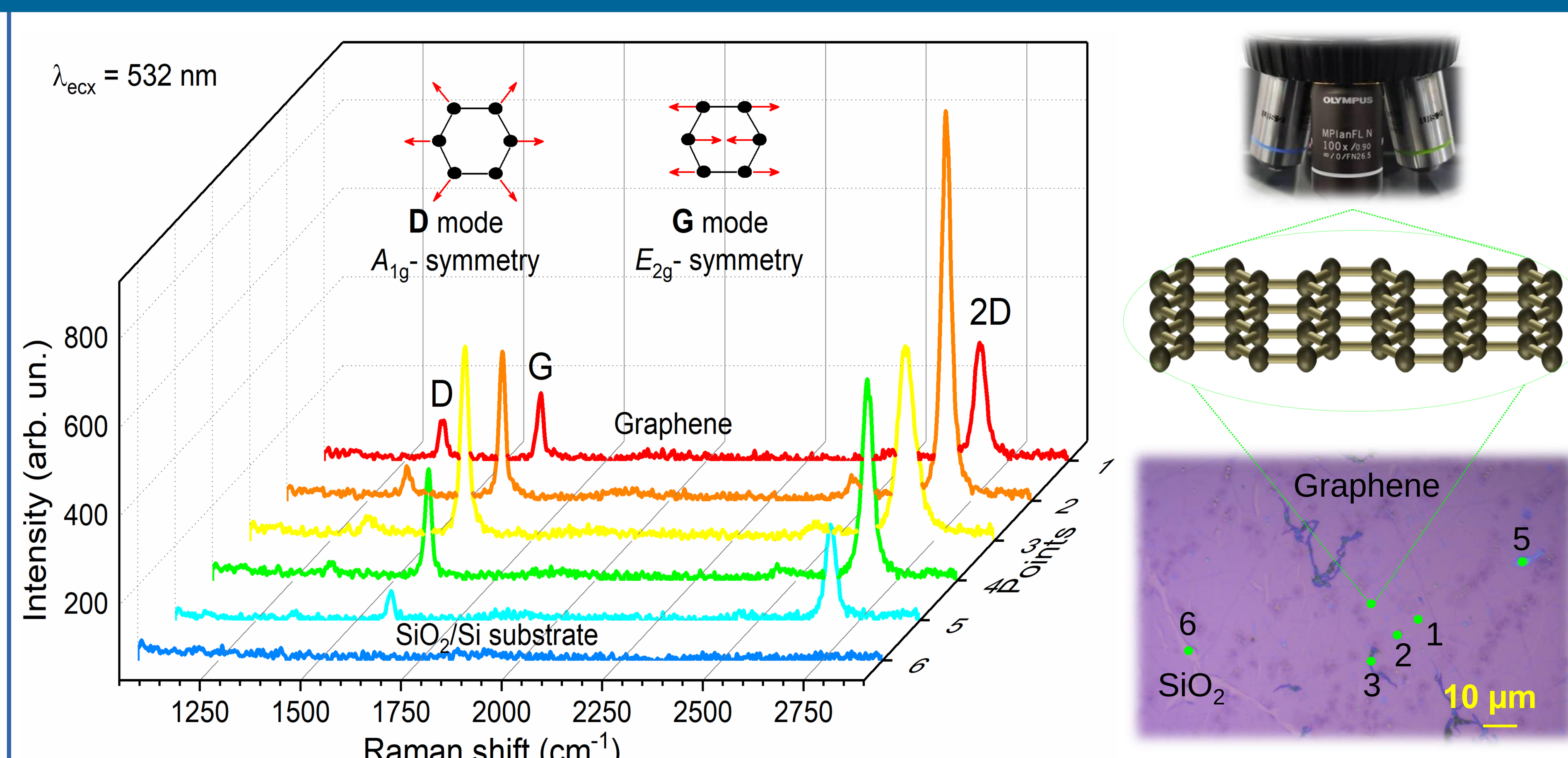
MORPHOLOGY



Optical surface morphology of graphene layer on Cu foil and covered by PMMA. Graphene layer transferred to Si/SiO_2 substrate with prepared Au contacts.

RESULTS AND DISCUSSION

In this investigation, monolayer graphene was transferred from Cu foil substrates to Si/SiO_2 for creating a field-effect transistor. The top side of the graphene on Cu foil was covered with polymethyl methacrylate (PMMA) by spin coating. The ammonium persulfate was used for releasing the graphene/PMMA layer. Thereafter, a prepared Si/SiO_2 wafer was slid underneath the floating graphene/PMMA and scooped off from the liquid solution. The substrate containing transferred graphene/PMMA was allowed to dry in air and then baked at 80°C (above the PMMA glass transition point) for 5 min to allow its reflow in order to reduce the wrinkles in graphene that originated while transferring on the substrate. Finally, the sample was dipped in acetone for 10 min (twice) to remove PMMA from the top of transferred graphene. Then, a prepared mask was used for obtaining gold contacts. At all stages of the transfer, Raman spectroscopy was used to get information about the quality of the graphene layer.



Raman spectra of a graphene monolayer on a Si/SiO_2 substrate at different points on the surface and an image of this layer in the objective lens of an optical microscope.

CONCLUSIONS

1. The method of transferring a graphene layer from one substrate to another has been developed.
2. The morphology of the transferred graphene layer was of good quality, which was confirmed by Raman spectroscopy.
3. Raman vibrational modes of graphene were responsible for the G-, D- and 2D-bands.
4. This investigation will allow to create high-quality field-effect transistors.

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