Electrochemical bubble transfer of Graphene and Raman characterization to create field-effect transistors

Chang Y.[1], Zhang J.[1], Chen W.[1], Babichuk I.S.[1,2], Yang J.[1]

1 Faculty of Intelligent Manufacturing, Wuyi University, 529020, Jiangmen, PR. China.

2 V. Lashkaryov Institute of Semiconductor Physics, NAS of Ukraine, 03680, Kyiv, Ukraine.

NANO 2023

INTRODUCTION

Graphene, being a sp_2-bonded cellular single-layer structure of carbon atoms, exhibits high carrier mobility and a large surface area per unit volume. These inherent characteristics make graphene a promising material for chemical sensors. A large surface to volume ratio of graphene makes it highly sensitive to certain environmental conditions, and its high mobility reduces the thermal noise, improving the detection limit. Due to these features, gas sensors that use graphene were studied and developed to measure O_2, CO, CO_2, H_2O, NH_3, and NO_2 concentration. We use the electrochemical bubble method to achieve the most efficient transfer of graphene from copper foil to a flexible substrate for the creation of flexible gas sensor devices.

In this investigation, monolayer graphene was transferred from a Cu foil substrate to polyethylene terephthalate (PET), for the creation of a flexible gas sensor. The surface of Cu foil graphene was coated with polymethyl methacrylate (PMMA) by spin coating. Using NaOH solution as the electrolyte, Pt as the positive electrode, Cu foil as the negative electrode, the electrochemical bubble method slowly released the PMMA/graphene. The residual NaOH solution on the surface was cleaned by DI, and the PET substrate was slid under the floating Graphene, and removed from the DI. The substrate with the transferred graphene was dried in air and then baked at 100 °C (7 min) above the PMMA glass transition temperature to reduce the wrinkles created when the graphene was transferred on the substrate. Finally, the sample was cleaned in acetone for 12h to remove PMMA from the graphene. At all stages of the transfer process, Raman spectroscopy was used to obtain information about the quality of graphene.

PREPARATION

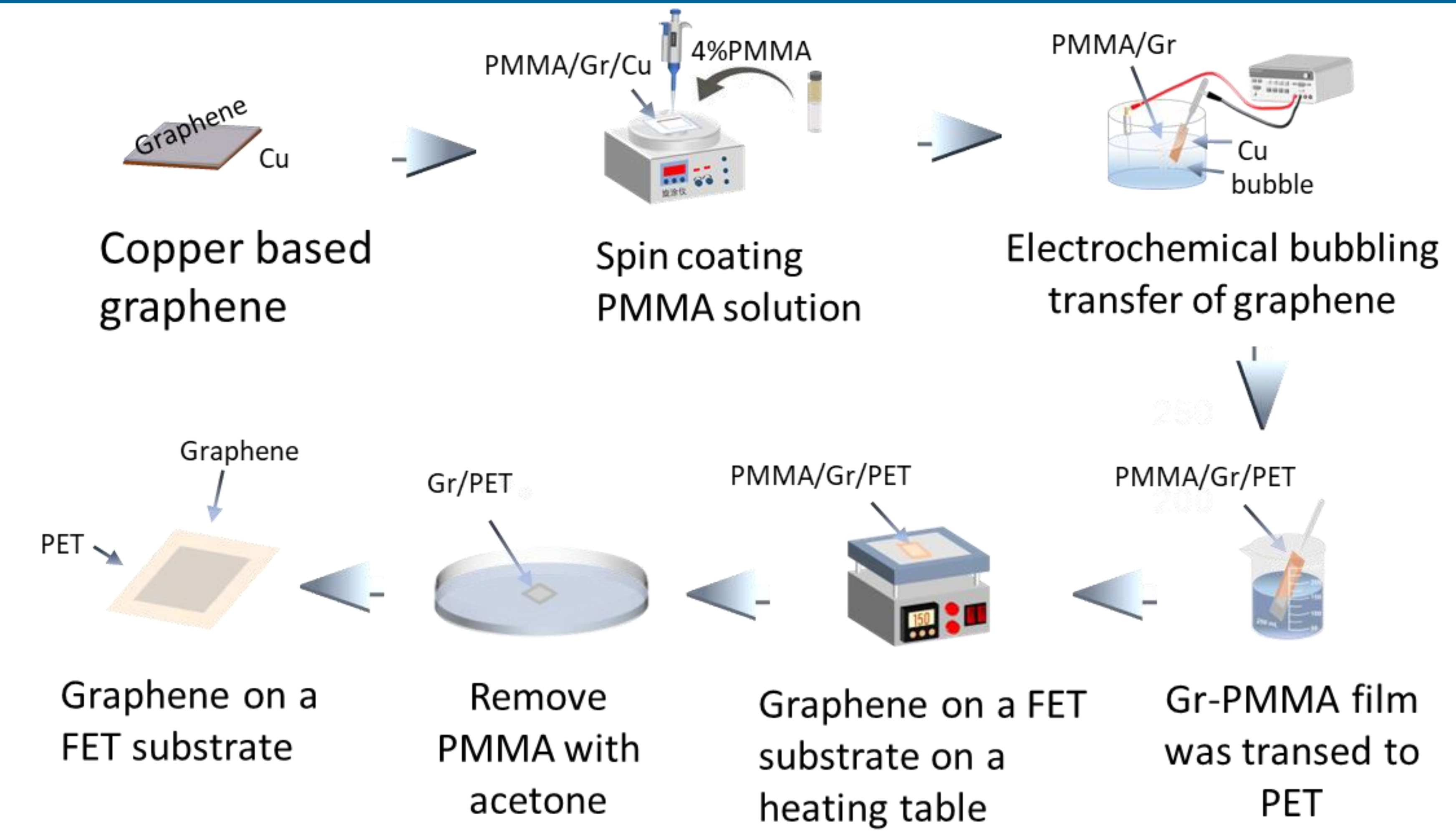
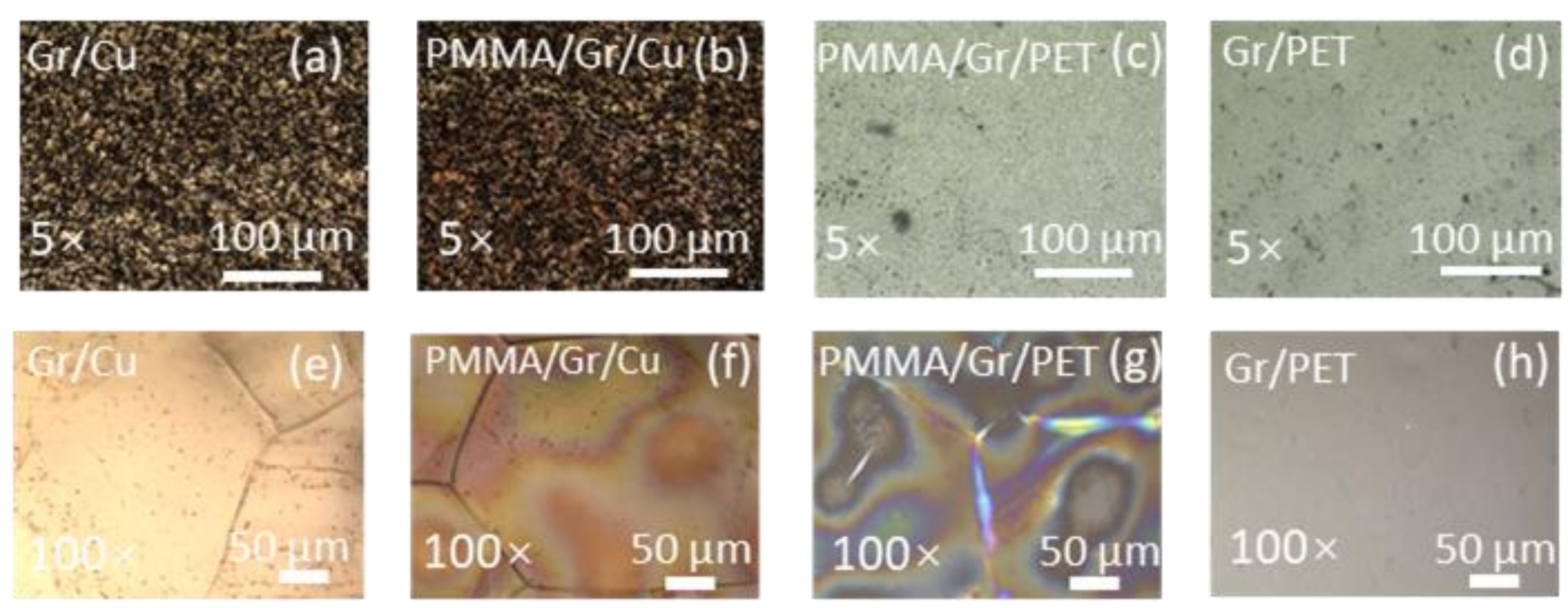


Illustration of the bubbling transfer process of graphene from a Cu substrate.

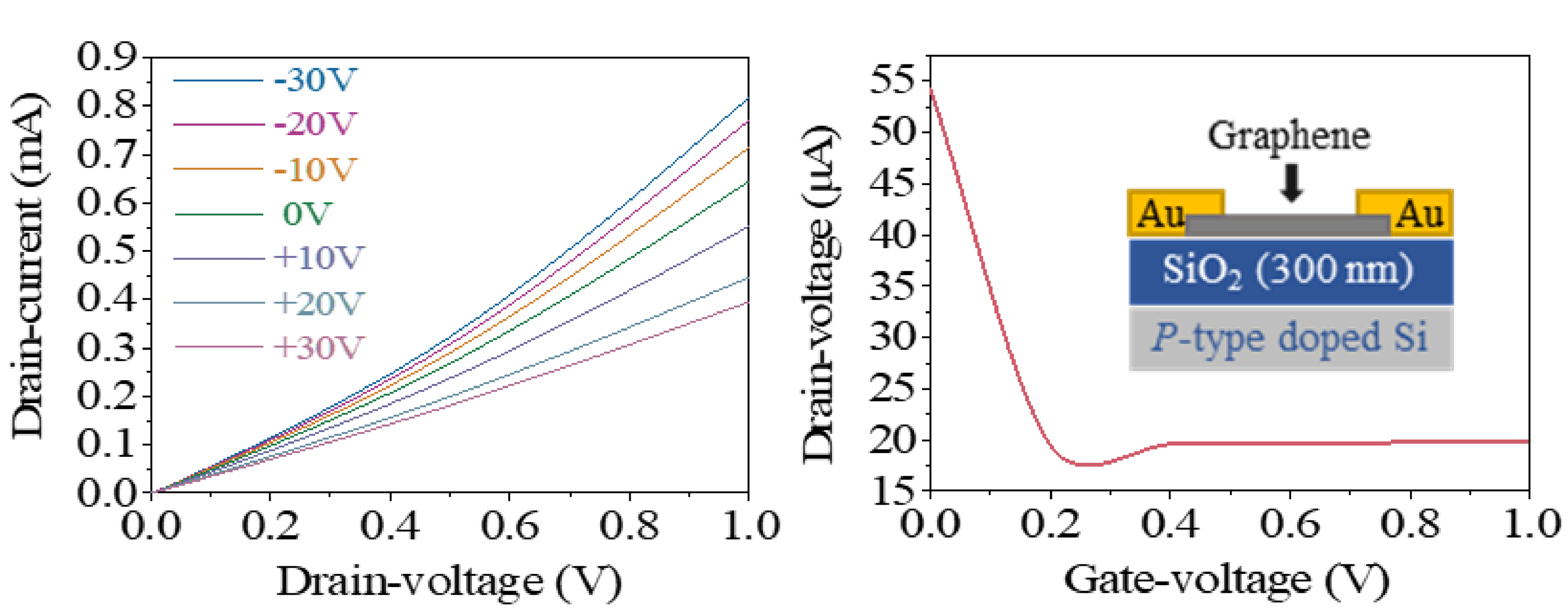
MORPHOLOGY



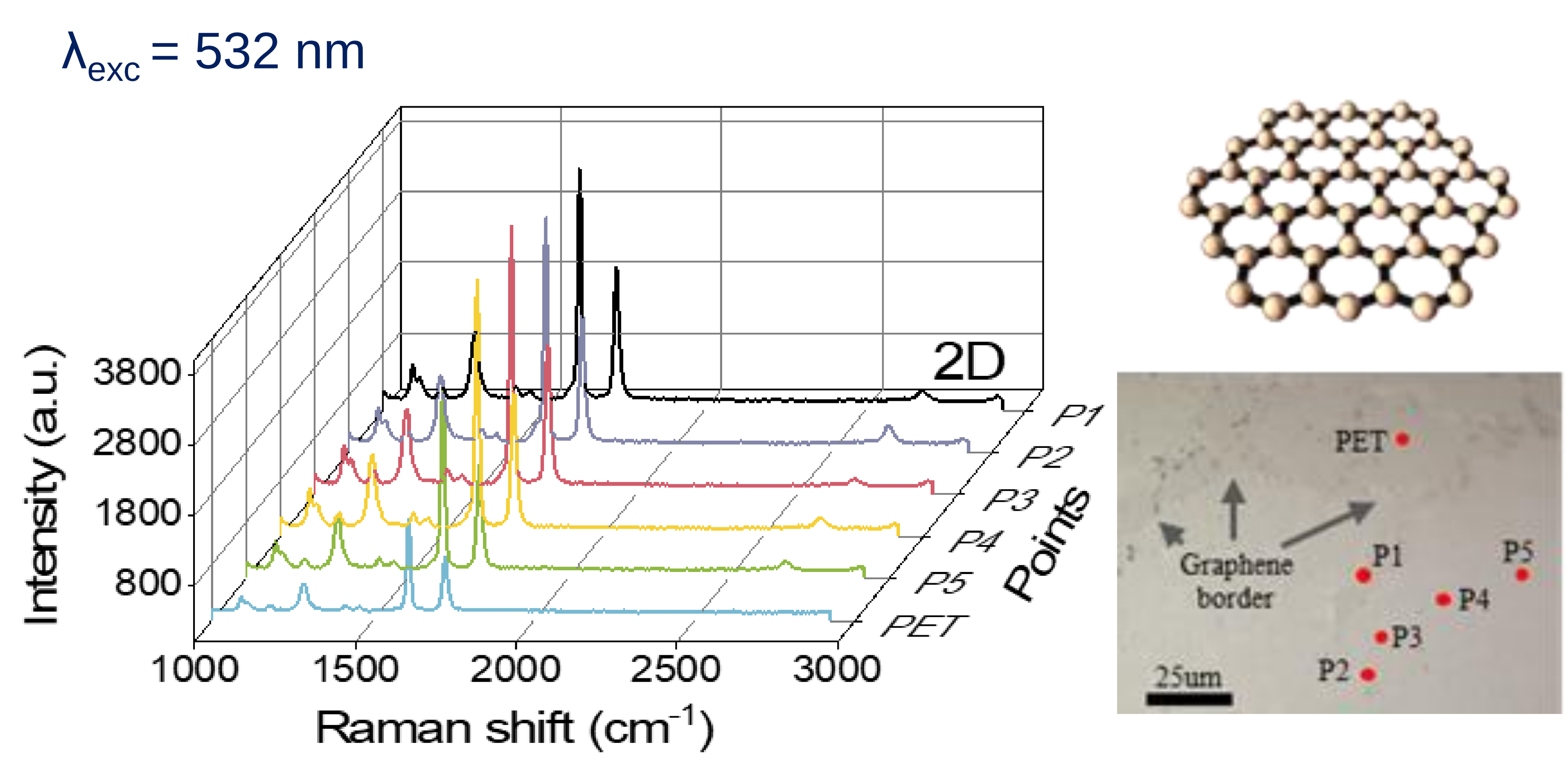
Optical surface morphology of the graphene layer at different stages of the transfer from a Cu foil onto PET substrate under 5X (a-d) and 100X (e-h) microscope objective.

RESULTS AND DISCUSSION

Before the fabrication of flexible graphene FETs on flexible substrate, we built typical bottom-gated graphene FETs on a SiO_2/Si wafer to examine the performance of graphene films.



(a) Output characteristic curves within the bias ranging from -30 V to +30 V, and (b) the transfer characteristic curve at V_{DS}=1V.



Raman spectra (left) of a graphene monolayer on PET substrate at different points on the surface indicated in the image (right).

CONCLUSIONS

1. The method of transferring the graphene layer from a copper substrate to the flexible one has been developed.
2. Good quality of the transferred graphene layer was confirmed by Raman spectroscopy.
3. FET sensor prepared using a transferred graphene film on the flexible substrate has a good electrical signal.

E-mail:
Chang yu
yu2212343677@163.com
Ivan S. Babichuk
ivan@szu.edu.cn
babichuk@isp.kiev.ua
https://www.wyu.edu.cn/