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2D MATERIALS INTEGRATION IN PHOTOELECTRIC DEVICES

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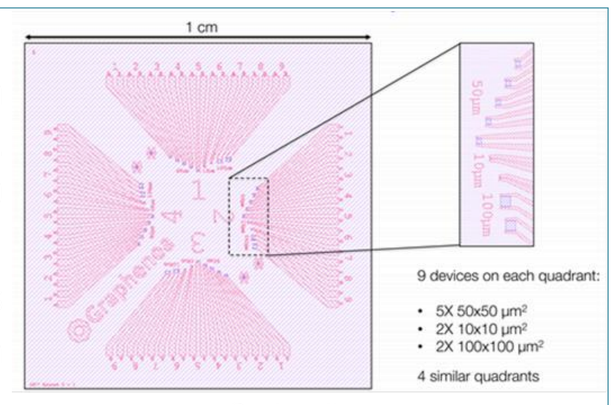
Introduction

Nowadays, 2D materials are known to present various properties. So they could be integrated in devices to allow some improvements and innovations as flexible devices[1] or biosensors[2]. However, 2D materials integration in devices is limited due to difficulties in handling of 2D materials.

The purpose of this work is to transfer MoS_2 on optoelectronic devices, develop integration steps for 2D materials and study the effect of MoS_2 on graphene. The devices with graphene have been prepared by Graphenea .

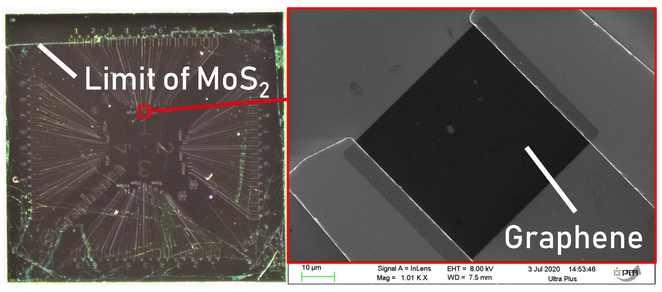


Device, diagram

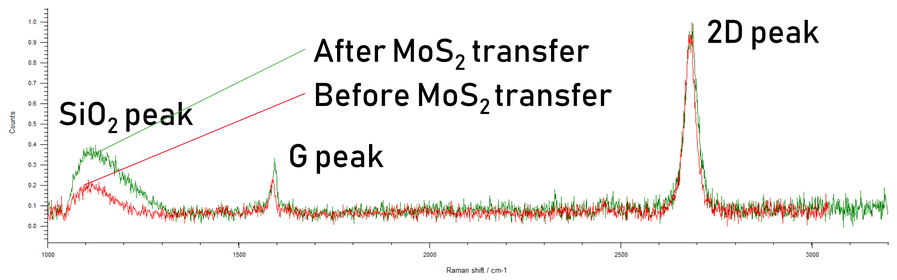
Double WET Transfer of 2D materials

Currently, 2D materials growth substrates are not appropriated to make devices (because of their chemical nature or damaging durong process). So Wet transfer was used with PMMA as support layer. It is the most used method currently even if it does not present a good reproducibility and it is not suitable for large areas as 300 mm wafers.

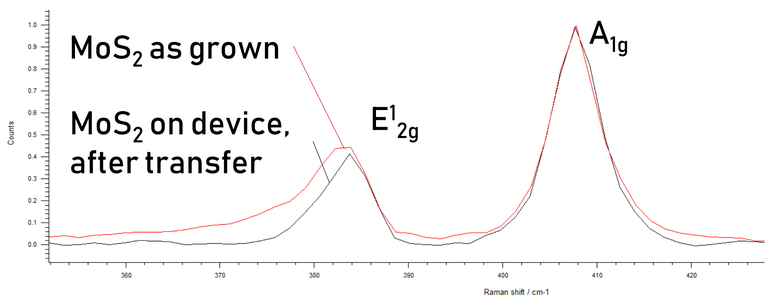
MoS_2 (6 Monolayers) were transferred on devices provided by Graphenea. While graphene is only present between metal electrodes, MoS_2 covers all devices. After transfer of MoS_2 on Graphenea devices with graphene, the quality has been checked by Raman spectroscopy. No difference is visible between MoS_2 and graphene spectra before and after transfer. The process of transfer does not seem to alter the materials.



2D films after transfer. At the left : MoS_2 on device, optical microscope. At the right, focus on graphene transferred below electrodes, SEM

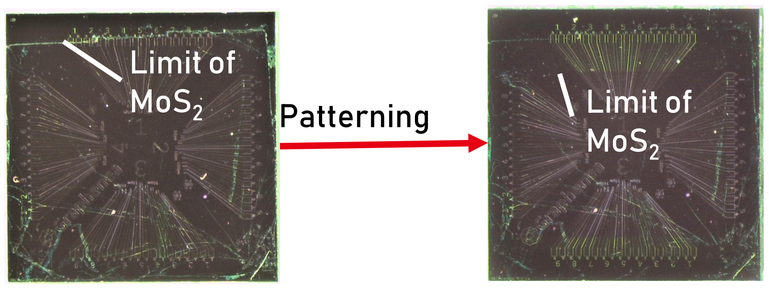


Raman spectra of graphene on device before and after MoS_2 transfer



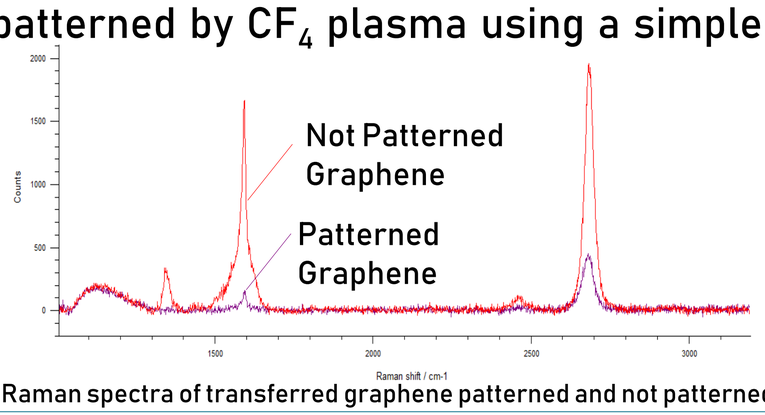
Raman spectra of MoS_2 as grown and after MoS_2 transfer, on device

Patterning of 2D materials



MoS_2 on device before and after plasma patterning

After wet transfer, MoS_2 film covers nearly the entire area of sample, including test electrodes. This configuration prevents proper subsequent electrical measurements. To release the metallic electrodes, MoS_2 was patterned by CF_4 plasma using a simple Si-wafer piece as mask. Raman spectroscopy does not show degradation for MoS_2 and graphene after patterning. Concerning graphene transfer, Raman spectroscopy shows lower intensity spectrum for transferred and patterned graphene (from Graphenea) than to simply transferred graphene (from our team), see beside. Then it seems that this patterning method could be harmful for 2D materials.



Raman spectra of transferred graphene patterned and not patterned

Discussion

Good results obtained here with Raman spectroscopy are not enough to prove the complete integrity of 2D materials. Indeed, integration steps could strongly impact 2D materials by introducing structural defects or contaminations. Slight pollution and holes would not be detected by Raman but have an incidence on electric properties as mobility in graphene[3].

Then, electrical measurement should be a good way to estimate the impact of integration steps on 2D materials. If this impact exists and if it is too important, integration steps must be modified or optimized. Low intensity on Raman spectrum for patterned graphene is maybe one evidence of impact caused be integration steps as graphene or electrodes patterning.

Conclusion

MoS_2 transfer above electrodes and graphene already transferred and patterned succeed without visible degradations in Raman spectroscopy. Electrical measurement must be done to confirm 2D materials preservation during these integration steps.

Furthermore, interfaces between 2D and electrodes should be investigated (chemical nature and properties) in devices given that they have large influence on contact resistance[4].

Finally, to make quality devices, integration steps have to be mastered to control generated interfaces and avoid defaults creation.

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