GRAPHENE AND 2DM VIRTUAL CONFERENCE & EXPO

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2D MATERIALS: TRANSFER FOR MICROELECTRONIC DEVICES

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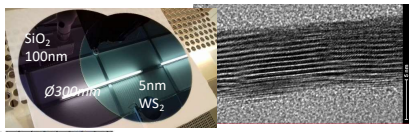
INTRODUCTION

2D materials present outstanding properties for a designer in microelectronics: various electrical behavior, flexibility, transparency… However, integrating 2D materials in microelectronics devices on large scale wafers is a challenge for the future. CEA-Leti brings together in a project many actors of large scale 2D growth, transfer of thin film and devices fabrication. The project aims the development of large scale 2D material integration for microelectronic devices.

LARGE SCALE 2D MATERIALS

CEA-Leti develops large scale 2D materials compatible with processes in clean room. We also collaborate with large scale 2D materials providers

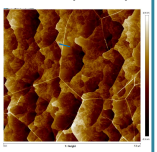
CEA-LETI



WS_2 on 300mm wafer

TEM image of SnS_2

Aixtron (collab)



Graphene on sapphire (AFM)

TRANSFER OF 2D MATERIALS

Often, growth substrates of 2D material can't be used for microelectronic devices:

X Growth of 2D materials on metals

X When a CMOS substrate is required, the chemistry of the growth process of 2D materials is hardly compatible with it

⇒ Transfer of 2D materials is required to do electronic devices

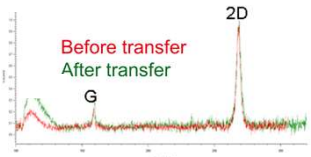
However transfer process of 2D materials for microelectronics devices is really challenging:

✓ It has to be compatible clean room processes

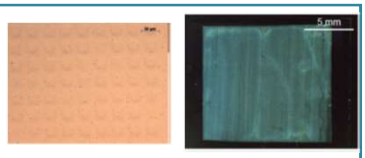
✓ It must be scalable until at least 200 mm

✓ Due to the 2D nature of the material, the cleaning of interfaces has to be perfectly controlled to preserve the properties of the 2D material

⇒ 2 processes are investigated here : "wet" process with polymer handle and "spalling" process with Ni handle

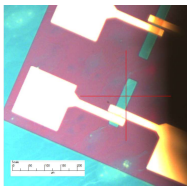


Raman spectra before and after transfer of graphene

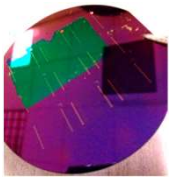


Transfer of MoS_2 on cavities (20 µm x 20 µm)

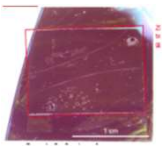
Transfer of graphene on « thick » electrodes

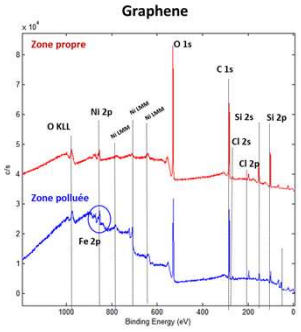


Wet transfer (4'' wafer) [1]



Spalling transfer





XPS study of contamination after spalling transfer

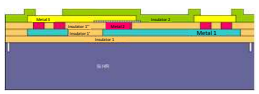
SWITCHING DEVICES

Two types of switching devices are studied in this project:

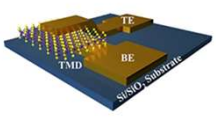
- RF switches
- Memories

A common design has been made to obtain RF switches, memories and electrical tests (like TLM, four probes…) on the same wafer.

2D materials will be deposited on a planarized surface to avoid the step between electrodes and substrate



Scheme of switching devices



Scheme of RF switch [2]

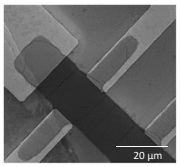
TRANSDUCERS

Two applications are targeted:

- Biological sensors
- Optoelectronic devices

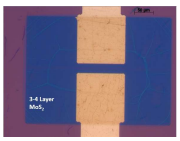
Several steps of MoS_2 integration into devices are studied:

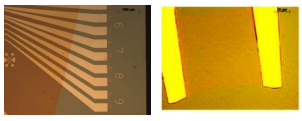
- Patterning of graphene and MoS_2
- Transfer of MoS_2 on Graphene
- Study of contact resistance of metal/Graphene/MoS_2 stack *vs* Metal/MoS_2 stack



Patterned MoS_2 on gold electrodes

Transfer and patterning of graphene and MoS_2 on sensors to reduce Rcontact





MoS_2 on graphene devices from Graphenea for optoelectronic devices

CONCLUSION

Our project brings together partners with different skills required to design and make 2D devices in clean room with CMOS compatible processes. The collaboration between teams working on large scale growth, transfer processes, characterizations and devices drives to a rapid progress in integration of 2D materials for applications. Targeted applications are RF switches, memories, biological sensor and optoelectronic devices. Future works will target on interfaces quality to avoid defects due to transfer and growth contamination,…

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REFERENCES

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2. Ge et al. Nano Lett. (2018), 18, 434-441

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