2024「中技社科技獎學金」

2024 CTCI Foundation Science and Technology Scholarship

境外生研究獎學金

Research Scholarship for International Graduate Students

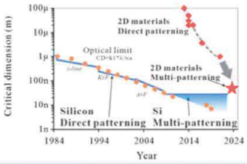
Self-expansion based multi-patterning for 2D materials fabrication beyond the lithographical limit

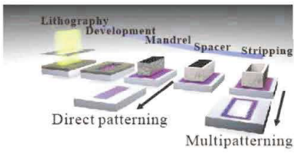
Poonam Borhade[1,2,3], **Ya-Ping Hsieh**[3], **Mario Hofmann**[1*]

Department of Physics, National Taiwan University, Taipei 10617, Taiwan.
Taiwan International Graduate Program, Academia Sinica, Taipei 10617, Taiwan.
Institute of Atomic and Molecular Sciences, Academia Sinica, Taipei, 10617, Taiwan
Email: mario@phys.ntu.edu.tw

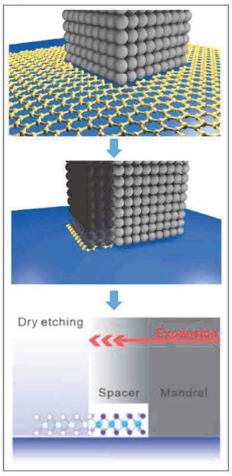
Introduction

Oxidative self-expansion double patterning (SEDP) process permit highly precise manipulation of the critical dimension in the nanometer-range, independent of the lithographic resolution. We demonstrate the potential of multi-patterning as a powerful platform for studying the integration of 2D materials into state-of-the-art, ultra-scaled devices.

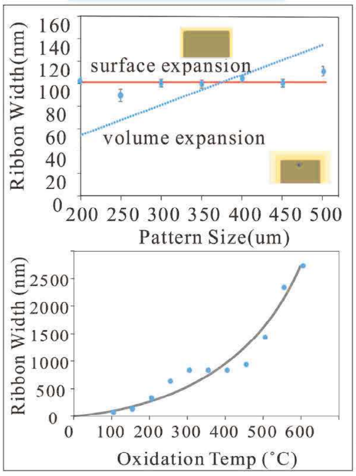




Approach



Mechanism



- SEDP process converts mandrel into the spacer. Surface oxidation of Aluminum achieves contact expansion
- Subsequent dry etching yields nanometer graphene patterns independent of lithographical resolution

Conclusions

SEDP approach provides a route towards fabrication of 2D ultra-scaled transistors for future electronics. Our approach is based on the combination of self-aligned process and lithographical patterning with high design flexibility and retention of 2D material quality. Approach is universally applicable to all 2D materials. It permits research into 2D material optimization and integration.

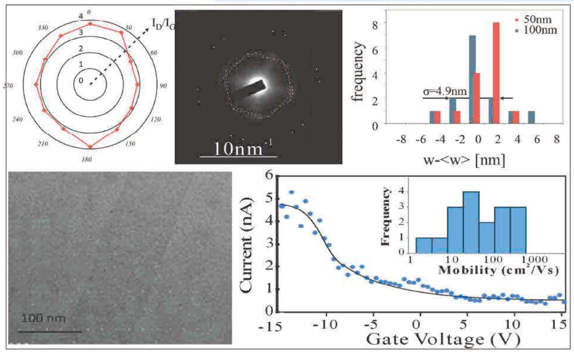
Selected Journal Publications

1. Self-Expansion Based Multi-Patterning for 2D Materials Fabrication beyond the Lithographical Limit. *Small* (2023): 2311209.
2. Transferrable Alumina Membranes as High-Performance Dielectric for Flexible 2D materials Devices. *Advanced Electronic Materials* (2024): 2300783.

Google Scholar ID

ORCiD ID

Nanoribbon Formation



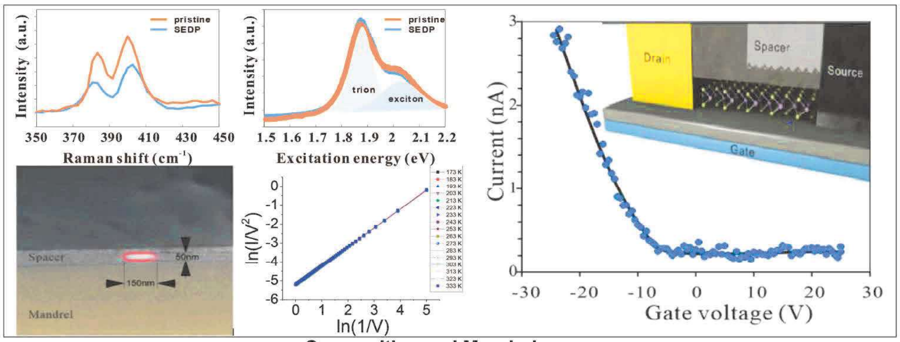
Characterizations

- Raman spectroscopy reveals defectiveness independent of ribbon width and polarization dependence due to edges
- Selected area diffraction demonstrates the presence of two distinct lattices with a rotational misalignment of 12°
- TEM demonstrates low roughness independent of ribbon width

Electrical Measurements

- Transconductance shows p-type behavior
- The average field effect mobility is 134cm²/Vs

Nanosheet Formation



Composition and Morphology

- Ultrathin 2D nanosheets are realized by self-expansion double patterning(SEDP) process
- Optical spectroscopy corroborates the retention of MoS_2 quality after processing.

Carrier Transport measurements

- Individual, 2D material nanosheets were integrated into FETs
- Carrier transport occurs through direct tunneling
- Edge-contacted MoS_2 nanosheet transistor demonstrates semiconducting p-type behavior with a field-effect mobility of 0.52cm²/Vs

Awards and Recognition:

2024 – Unique Presentation Award in 15th Hope Meeting with Nobel Laureates
2024 – National Science and Technology Council (NSTC) Grant for Doctoral Student Attending International Conference Abroad
2023 – Institute of Atomic and Molecular Science Young Fellow Research Best Poster Presentation Award
2023 – IAMS – NTNU-YCU Autumn Workshop 2023 (INY 2023) Best Oral Presentation Award
2019 – Academia Sinica AS-Taiwan International Graduate Program (TIGP) Doctoral Fellowship

財團法人中技社
CTCI FOUNDATION