Single layer CVD MoS2 for flexible electronics

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SINGLE LAYER CVD MoS_2 FOR FLEXIBLE ELECTRONICS

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Two dimensional layered semiconductors, and in particular transition metal dichalcogenides such as molybdenum disulfide (MoS_2), have recently received increasing attention due to the combination of their unique electronic properties with their atomically thin geometry. In particular, single-layer MoS_2 possesses key properties that make it especially appealing as channel material in flexible field-effect transistors: a sizable band-gap, mechanical robustness, absence of dangling bonds / chemical stability, appropriate electron mobility, compatibility with room-temperature transfer and device fabrication process-flows.

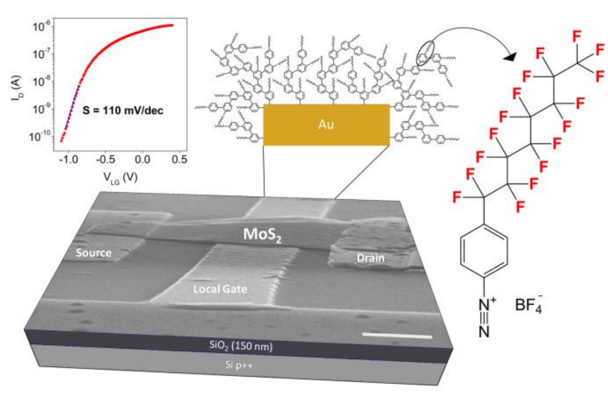
Among the numerous issues that need to be solved, two are of particular importance: (1) MoS_2 must be grown at a large-scale and at low-cost while achieving crystalline quality comparable to exfoliated layers from natural crystals, (2) MoS_2 should be associated with other flexible elements within the FETs notably high-quality flexible insulators as gate dielectrics. At the GDRI-GNT conference, we would like to present our recent contributions to these questions.

We synthesized single-layer MoS_2 by CVD and optimized the conditions to grow either large-size individual triangular domains (up to 100µm large) or fully-covering domains (cm^2 scale). Extensive characterizations allowed assessing the material quality. We then integrated this material in rigid and flexible FETs.

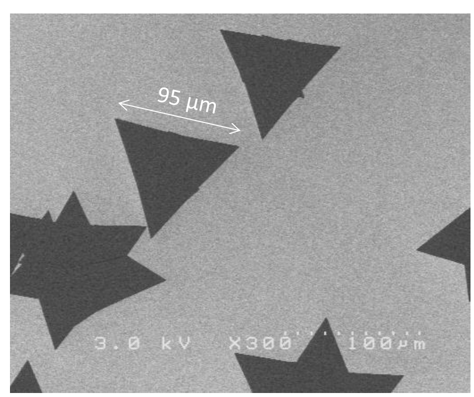
In parallel we studied a new class of gate dielectrics based on electro-grafted organic thin films. These robust covalent organic dielectrics are produced at room temperature and under mild conditions. The process yields uniform films of adjustable thickness (in the 4-50 nm range depending on the molecular compounds and grafting parameters). We first build transistors combining exfoliated MoS_2 as channel material with one example of such new dielectrics on rigid substrates [1]. The transistors operate at low bias (gate swing of 1.5V and V_{DS}=0.5V), exhibit steep subthreshold slope as low as 110 mV/decade and are hysteresis-free due to the hydrophobic and trap-free nature of this dielectric. Very recently, we showed, using a different organic compound, that this approach can be combined with single-layer CVD MoS_2 and integrated on flexible substrates [2].

References

[1] H. Casademont, L. Fillaud, X. Lefèvre, B. Jousselme, V. Derycke. *J. Phys. Chem. C* **120**, 9506 (2016).
[2] H. Casademont, Y-P. Lin, R. Cornut, B. Jousselme, V. Derycke, *"Combining single-layer CVD MoS_2 and a new class of electro-grafted organic dielectric in FETs on flexible substrates", in preparation.*



SEM image and schematic representation of a transistor using a hydrophobic organic electro-grafted thin film (4-7 nm) as gate dielectric and mechanically exfoliated MoS_2 as channel. Transfer characteristic at V_{DS}=0.5V.



SEM image of individual single-layered MoS_2 domains grown by CVD on Si/SiO_2.

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