The MBE Laboratory for van der Waals epitaxy of 2D layered heterostructures at IMM-CNR Lecce

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Van der Waals epitaxial (vdWE) heterostructures of crystallographically-oriented 2D materials offer a unique playground to tailor the physical properties of individual 2D materials by assembling them into novel 2D structures [1]. A series of emerging applications in electronics (FET, simple logic circuits, flexible transistors) and atomically thin opto-electronic devices (LEDs, laser diodes, PV cells, molecular sensors) have been demonstrated in the literature. However, most of these studies relies on device fabrication by mechanical stacking of single 2D monolayers onto a given substrate or another 2D material [2], so to obtain the desired 2D heterostructure. While this approach allows to obtain 'proof-of-concept' devices, it does not grant large-area industrial-scale production.

The grow of defects-free and azimuthally oriented 2D materials with control at the atomic-layer level is still a very challenging task. In recent years, the molecular beam epitaxy (MBE) growth of 2D materials has begun to be explored [3] as a viable alternative to chemical vapor deposition (CVD) for the sequential vdWE growth of 2D heterostructures on both metal and insulating substrates. Advantages of MBE technology over CVD methods are: (i) the occurrence of a self-limiting growth mechanism of 2D materials; (ii) the possibility to perform in-situ surface-science characterization, due to UHV conditions, and (iii) much easier control of monolayer growth over large diameter size.

In this contribution, we describe the MBE facility for the vdWE of 2D materials recently installed at CNR-IMM in Lecce within the framework of the PHASHYN Project funded by Regione Puglia. The MBE reactor consists of a RIBER Compact 21 CLS system [Figure 1] specifically designed to ensure deposition of 2D materials over a 2" dia. wafer, and process temperatures up to 1500°C. At present the reactor is equipped with a C sublimation source (heated up to 2300°C), utilizing a pyrolytic graphite filament, for graphene growth, but it has several UHV spare-ports; thus, its configuration can be upgraded with up to 7 sources to perform vdWE of hBN and transition metal dichalcogenides. The reactor is equipped with a RHEED system operating with a 12-keV electron beam for in-situ monitoring. The facility, the first one of its kind in Italy, is hosted inside the Semiconductor Physics and Technology Laboratory of University of Salento.

References

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Figures

Figure 1. Photograph of the MBE facility installed at IMM-CNR in Lecce.