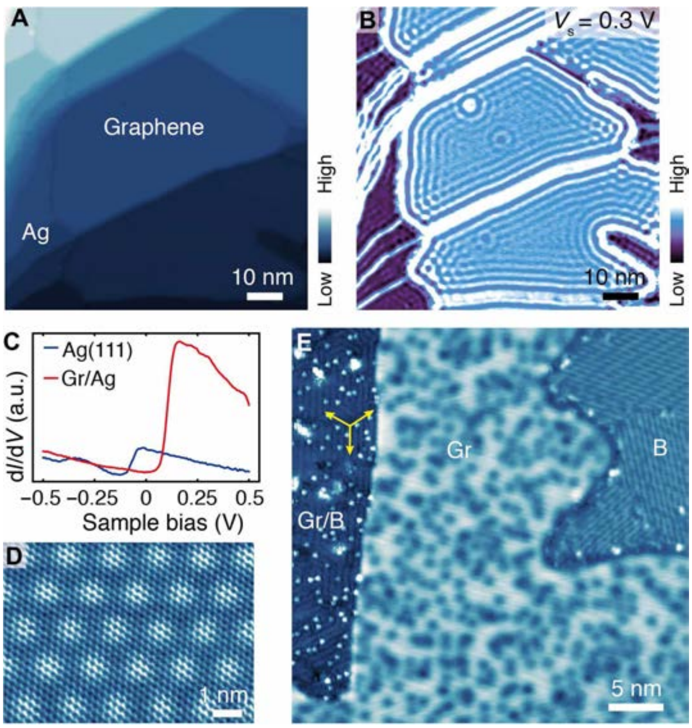
Application Note

GROWTH OF 2D MATERIALS WITH E-BEAM EVAPORATION

FOCUS EFM 3

Two-dimensional (2D) layered materials, such as Graphene, Boron Nitride (BN) and Transition Metal Dichalcogenides (TMDCs), have attracted great interest in materials research, due to their excellent electronic, optical and mechanical properties.
2D materials will play an important role in the applications of next-generation nanoelectronics, sensors, optoelectronics, energy conversion and storage.

The EFM 3 is the ideal tool to deposit such ultra pure materials for new materials research due to its precise control of temperature and flux under clean UHV conditions.



GRAPHENE & BOROPHENE- GRAPHENE HETEROSTRUCTURES ON Ag(111)

Figure 1* (a-e)
a) STM topography image of as-grown single-layer Graphene on Ag(111)
b) The corresponding differential tunneling conductance map.
c) Differential tunneling conductance curves measured on Ag(111) and Graphene (Gr/Ag)
d) STM topography image of as-grown graphene
e) STM topography image of lateral and vertical heterostructures between Borophene and Graphene.

Linear features in three directions are indicated by the yellow arrows in the region of Borophene-intercalated Graphene (Gr/B).

Growth parameters

Borophene growth by E-Beam evaporation, using a FOCUS EFM 3 and a pure Boron rod (diameter, 3 to 5 mm; purity, 99.9999%); at 50 W and 1.75 kV.

Graphene growth by E-Beam evaporation using a FOCUS EFM 3 and a pure Graphite Carbon rod (diameter, 2.0 mm; purity, 99.997%), at 140 W and ~2 kV.

FOCUS GmbH, D-65510 Huenstetten-Kesselbach, Germany
Tel.: +49 (0)6126-4014-0, Fax.: +49 (0)6126-4014-10
Web: www.focus-gmbh.com, Mail: sales@focus-gmbh.com

All about electrons...

2D transition-metal dichalcogenides molecular-beam epitaxy of monolayer and bilayer WSe2 & MoSe2

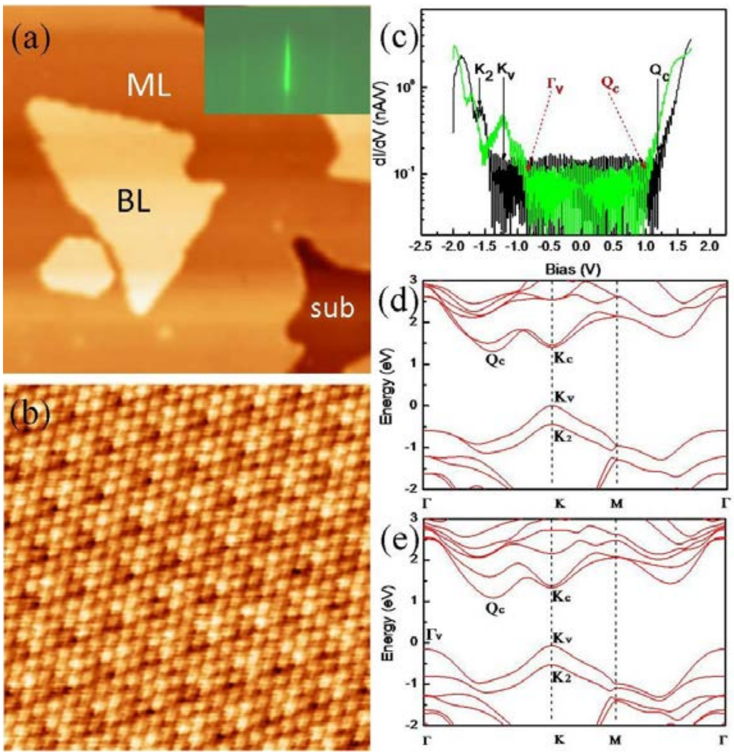


Figure 2**
STM micrograph (size: 75×75 nm2)
STM/S of MBE-Grown ML and BL **WSe_2**
a) MBE-grown **WSe_2** film with the nominal thickness of 1.2 MLs, showing ML and BL domains. Holes of exposed substrate surface are also visible. The inset shows the RHEED pattern taken along [1120] of the surface.
b) STM image (7.5×7.5 nm) of the ML **WSe_2** domain of the sample revealing the moiré pattern but no line defect.
c) STS differential conductance spectra of ML (black) and BL (green) **WSe_2**. The critical point energies are indicated by solid (for ML) and dashed (for BL) arrows.
d) Theoretical band structures of ML **WSe_2**
e) Theoretical band structures of BL **WSe_2**

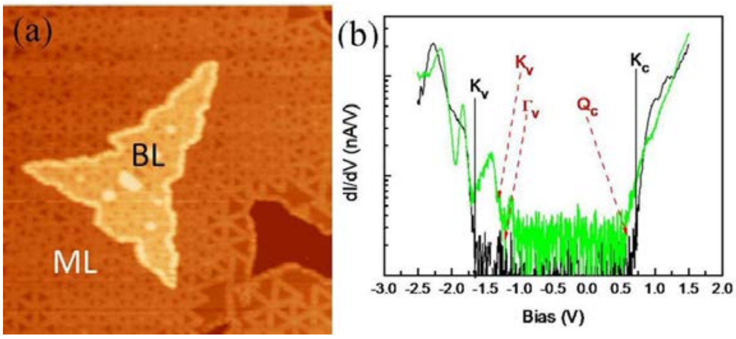


Figure 3**
STM/S of ML and BL **$MoSe_2$**
a) STM image (100×100 nm, sample bias: -1.0 V) of an as-grown **$MoSe_2$** film of the nominal thickness of 1.4 MLs, showing the network of domain boundary defects (the bright lines) in both ML (darker area) and BL (brighter area domains.
b) STS differential conductance spectra of ML (black) and BL (green) **$MoSe_2$**.

**„Growths of WSe_2 (and $MoSe_2$) ultrathin films were carried out in a customized Omicron MBE system with the base pressure of in the low 10^{-10} mbar range Elemental W and Mo metal wires were used as the metal sources in the EFM3 e-beam evaporators without ion filtering) [...]“

*Xiaolong Liu et al 2019 Science Advances
Northwestern University, Evanston, IL USA
Doi.org/10.1126/sciadv.aax6444

**H J Liu et al 2015 2D Mater. 2 034004
Physics Department, University of Hong Kong
doi.org/10.1088/2053-1583/2/3/034004