

# Molecular beam epitaxial growth of hexagonal boron nitride on Ni

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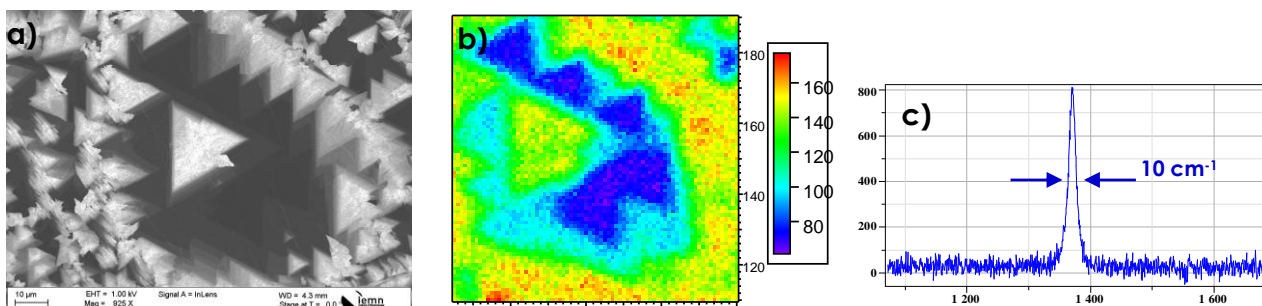
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Developing nanoelectronics devices based on graphene is a highly active research domain. Many studies have shown that heterostructures involving graphene and hexagonal boron nitride (h-BN) are very attractive in this domain. In particular, h-BN is very efficient to preserve the electrical properties of graphene, thanks to its insulating properties related to a large band gap (~6 eV) and to its 2D character.

Unlike most of the growth studies published to date (involving chemical vapor deposition), we use gas-source molecular beam epitaxy to synthesize h-BN on polycrystalline or monocrystalline Ni. The precursor was gaseous borazine ( $B_3N_3H_6$ ), associated or not with active nitrogen generated by a RF plasma source. The growth temperature, borazine/N ratio and duration were optimized. To understand the nucleation and the growth behaviour of h-BN on Ni, we combine Raman and X-ray photoemission spectroscopies (XPS) with time-of-flight secondary ion mass spectrometry (ToF-SIMS), scanning electron microscopies (SEM), cathodoluminescence (CL) and high spatial resolution core-level photoemission spectroscopy.

When using only the borazine, ToF-SIMS and XPS analysis carried out before and after transfer on Si demonstrate the growth of a homogeneous film of h-BN. Quantitative analysis of the XPS spectra shows that the h-BN thickness slightly exceeds 1 monolayer. The growth of a thicker BN was obtained when combining borazine to activated nitrogen. While varying the growth temperature and the borazine/N ratio, SEM observations show that BN evolves from weird shaped to triangular islands (Fig. 1a). The size of these domains reaches 10-15  $\mu m$  when increasing the growth time. Raman (Fig. 1c) and CL spectroscopy reveal that a high quality BN is obtained at 910°C. Above 910°C, the BN growth is limited, probably because of a sublimation phenomenon. The nucleation density and the shape of the BN domains are clearly related to the way the Ni substrate is prepared. Indeed, we find that an annealing (before growth) beyond 1000°C significantly increases the nucleation density, but leads to BN whose crystallographic quality remains to be improved. The boron and nitrogen XPS peaks might include several components (up to 2 for N1s and 3 for B1s). Based on high spatial resolution core-level photoemission spectroscopy (Fig. 1b), we discuss the origin of the two main components of boron and nitrogen and their possible relationship with an electronic coupling with Ni depending on the thickness of BN.



**Figure 1:** a) SEM observations of BN triangular domains (growth at 910°C), b) N1s core level intensity map of the same area shown in a and c) typical E<sub>2g</sub> Raman spectra associated to BN islands.