Atomic layer deposition of boron nitride on carbon nanotubes for fabricating one-dimensional van der Waals heterostructures

Catherine Journet[1]
Ali Hossain[1], Antonin Louiset[2], Hanako Okuno[2], Salomé Forel[1], Catherine Marichy[1]
[1] *Laboratoire des Multimatériaux et Interfaces, UMR CNRS 5615, Univ Lyon, Université Claude Bernard Lyon 1, F-69622 Villeurbanne, FRANCE*
[2] *IRIG/MEM/LEMMA, CEA-Grenoble, 17 Avenue des Martyrs, 38054 Grenoble Cedex 09 FRANCE*
catherine.journet@univ-lyon1.fr ; catherine.marichy@univ-lyon1.fr

The emergence of graphene sparked widespread interest in two-dimensional (2D) materials, with subsequent exploration of their stacking into van der Waals (VdW) heterostructures, offering a plethora of potential applications. Beyond 2D materials, the concept of VdW heterostructures extends to one-dimensional (1D) systems, in which distinct materials are coaxially stacked, taking advantage of VdW coupling to merge their intrinsic properties or induce new ones [1]. Here, we focus on the fabrication of 1D VdW heterostructures by depositing atomic layers of boron nitride (BN) on carbon nanotubes (CNTs), intending to enrich the optoelectronic properties of the initial structures [2].

Employing a two-step atomic layer deposition (ALD) process based on polymer-derived ceramics chemistry [3], a polyborazine preceramic layer is first deposited on single- or multi-walled CNTs, followed by high-temperature treatment to convert it into crystalline BN. Advanced characterization techniques reveal the successful fabrication of highly crystalline BN/CNT heterostructures, with electron energy loss spectroscopy demonstrating conformal and homogeneous coating of BN layers on CNTs. In-depth exploration of ALD parameters and post-annealing treatments sheds light on the growth of BN, including thickness, number of layers, and homogeneity, as well as its structural phases. The influence of the starting carbon material on the morphology and crystallinity of the final heterostructures is also investigated. Complementary analyses, including Raman and photoluminescence spectroscopies, are carried out to assess the structural and optical properties of the resulting heterostructures.

References

[1] Xiang R *et al.*, Science, 367 (2020) 537–42.
[2] Marichy C *et al.*, Coord. Chem. Rev., 257 (2013) 3232–53.
[3] Hao W et al. ChemNanoMat 3 (2017) 656–63.

Figures

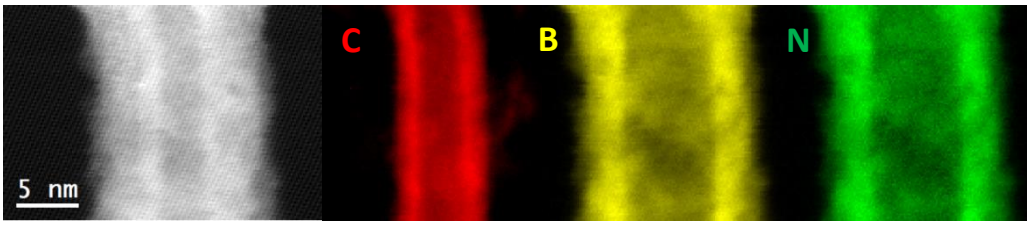

Figure 1: Scanning TEM image of BN-coated multi-wall CNT and its corresponding C (red), B (yellow), and N (green) elemental EELS mapping