Towards a scalable synthesis of van der Waals heterostructures: from graphene on h-BN to WS_2 on 2D substrates

Neeraj Mishra[1], Antonio Rossi[1,2], Holger Buech[1], Vaidotas Miseikis[1], Carmine de Rienzo[1,2], Domenica Convertino[1,2], Ameer Al-Temimy[1], Mauro Gemmi[1], Vincenzo Piazza[1], **Camilla Coletti[1]**

[1] Center for Nanotechnology Innovation @ NEST, Istituto Italiano di Tecnologia, Piazza San Silvestro 12, 56127 Pisa, Italy
[2] Laboratorio NEST – Scuola Normale Superiore, and Istituto Nanoscienze – CNR, Piazza San Silvestro 12, 56127 Pisa, Italy

Two-dimensional (2D) heterostacks are typically obtained by mechanical exfoliation of 3D crystals and a cumbersome process of mechanical assembly. The limited lateral dimension of the resulting samples restricts the access to conventional techniques for fundamental studies and is a serious hurdle towards the implementation of a scalable technology. Chemical vapour deposition (CVD) is presently considered the most feasible approach towards a scalable synthesis of 2D heterostacks. In this talk, advances in the synthesis of van der Waals heterostructures will be presented. We have recently developed a catalyst-free process for the rapid synthesis of single-crystal graphene on h-BN with growth rates as high as 100 nm/min [1]. Our results indicate that hydrogen is the main driving force for engineering graphene crystallinity. Combined atomic force microscopy (AFM) and Raman spectroscopy show that circular grains obtained for low hydrogen partial pressures are polycrystalline. On the contrary, high hydrogen partial pressures yield single-crystal hexagonal-shaped graphene grains perfectly aligned to the h-BN substrate. Furthermore, we report on the scalable synthesis of the optoelectronically appealing WS_2 on a variety of substrates. Notably, monolayer WS_2 is obtained not only on classical 3D dielectrics but also on 2D films such as graphene and h-BN. Relevant properties of the synthesized heterostacks will be discussed.

[1] N. Mishra et al., Carbon 96, 497–502 (2016).