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Department of Electrical Engineering
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Engineering Building B (ENB B), Room 118

CVD Synthesis of High-Mobility Graphene and Tailored Van Der Waals Heterostacks for Optoelectronic Applications

Abstract

Although obtained with a cost effective approach, CVD graphene on Cu was up to recently not preferred for electronic and photonic applications due to its polycrystalline nature and consequently impoverished electronic performances. In the last couple of years significant steps forwards have been made and a number of groups have reported on the synthesis of mm-sized single-crystal graphene on Cu. However, long growth processes are typically needed for the synthesis of grains with lateral size of 1 mm. Recently, we showed that single crystals of graphene with dimensions up to 3.5 mm can be obtained in just 3 hours using a commercially available cold-wall CVD reactor [1]. The key-steps of the process are: i) using (ex-situ) passivated Cu foils, ii) pre-annealing in an inert argon atmosphere, and iii) enclosing the sample during growth to reduce the impingement flux. The process is also appealing with respect to safety: high crystal growth rates can be achieved without hydrogen and with extremely low methane concentrations. This is key for potential industrial implementation. For the synthesized graphene single-crystals, we have measured remarkable transport properties, even on non-ideal Si/SiO_2 substrates, such as mobilities of 12000 cm^2/Vs and up to 12 well-defined Landau levels [2]. By presenting transport properties entirely comparable to those of exfoliated flakes, such CVD graphene single-crystals are extremely appealing for optoelectronic applications. CVD can be also successfully used as a scalable technique to synthetize highly-crystalline van der Waals heterostructures. Concerning CVD graphene on hBN, it has been shown that high growth rates (i.e., > 100 nm/min) require complex steps, such as the introduction of gaseous catalysts (e.g., germane and silane) during growth [3]. Our work demonstrates that graphene growth rates higher than 100 nm/min can be achieved on well-prepared bare hBN substrates [4], thus greatly simplifying the process. Finally, we will discuss a cost-effective vapor-phase reaction of solid powders which allows to obtain continuous atomic-thick layers of the optoelectronically appealing WS_2 on two-dimensional substrates such as graphene and hBN. The synthesized films display a robust polarization conservation at room temperature, as high as 74%. We show that by adopting epitaxial graphene on SiC as growth substrate, one can define in a bottom-up fashion photoemitting and photoconducting ribbons. The scalable synthesis and design on 2D substrates of WS_2 films with outstanding optical properties is instrumental in the development of novel all-2D quantum optoelectronic and valleytronic devices.

Biography

Camilla Coletti received her MS degree in electrical engineering from the University of Perugia (Italy) in 2004 and her PhD degree in electrical engineering from the University of South Florida (USA) in 2007. From 2008 to 2011 she was first a Max Planck postdoctoral fellow and then an Alexander von Humboldt postdoctoral fellow at the Max Planck Institute for Solid State Research of Stuttgart (Germany). During her research career she has accumulated a broad range of experimental experience in different fields such as chemical vapor deposition (CVD) growth, semiconductor/cells hybrid systems, and surface science. She is particularly expert on the CVD synthesis and characterization of carbon based materials, especially graphene. She is a skilled user of several spectroscopic and microscopic characterization techniques and has extensive experience at synchrotron facilities. She is active part of the graphene scientific community since 2008. Her contributions to the field include – for example – the development of the hydrogen intercalation technique, which is used to decouple graphene from the underlying SiC substrate, and the realization of transfer doping via molecular adlayers. From 2011 to 2016 she worked first as a postdoc and then as a researcher at the Center for Nanotechnology Innovation @ NEST in Pisa, where she personally set-up and developed a laboratory for the CVD synthesis and the characterization of graphene and other 2D materials. Since April 2016 Camilla Coletti is the Principal Investigator of the research line 2D Materials Engineering (TT1 Researcher) of the Istituto Italiano di Tecnologia (Pisa). She is the IIT responsible for the work-package Enabling Materials (WP3) of the European Flagship Project. She is author of about 50 peer-reviewed publications, holds 2 international patent, authored 4 book chapters, and gave more than 30 invited/keynote talks.