Upscaling $MoSe_2$ and hBN via controlled chemical vapor deposition

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Two-dimensional materials (2DM) are a topic of high interest in the materials science community to engineer innovative devices. Among them, hexagonal boron nitride (hBN), an insulator with structure similar to graphene, is an optimal candidate to serve as insulating/passivation layer in graphene-based devices, enabling high carrier mobilities [1]. Semiconducting 2DMs have shown outstanding optoelectronic properties, such as thickness-dependent photoluminescence, combined with lightweight and flexibility [2, 3]. In particular, atomically thin MoS_2 and $MoSe_2$ have been proposed and applied in several electronic devices [4]. Notwithstanding a considerable effort, a production method for 2DMs that would guarantee large scale, high throughput and low cost is still lacking. Chemical vapor deposition (CVD) is perhaps the most promising route for the batch production of 2DMs with high quality, but a few crucial challenges need to be addressed to attain cost-effective and reproducible processes over large areas. In this work, we report the growth of atomically thin $MoSe_2$ and hBN by atmospheric-pressure CVD. The samples were evaluated by electron microscopy and atomic force microscopy, as well as Raman and X-ray photoelectron spectroscopy. We adopted two different paths for the growth of $MoSe_2$ on two substrates (*i.e.*, soda lime glass and SiO_2), using Se powder and Mo foil or Mo powder as solid precursors (Figure a). By tuning the process parameters, i) monolayer $MoSe_2$ flakes with large area were grown on glass which showed intense photoluminescence at ~1.57 eV (Figure b) and ii) continuous polycrystalline $MoSe_2$ films were grown on SiO_2. By comparing samples grown in the same conditions on the two substrates, we studied the mechanisms involved in the processes. The 2D $MoSe_2$ materials can be integrated in optoelectronic devices, such as photodetectors, taking advantage of their high photo-responsivity. hBN was grown on Cu foil and transferred to SiO_2 via wet-etching method. We obtained continuous hBN samples with areas up to several cm^2, keeping the thickness within 5 nm (Figure c).

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FIGURES

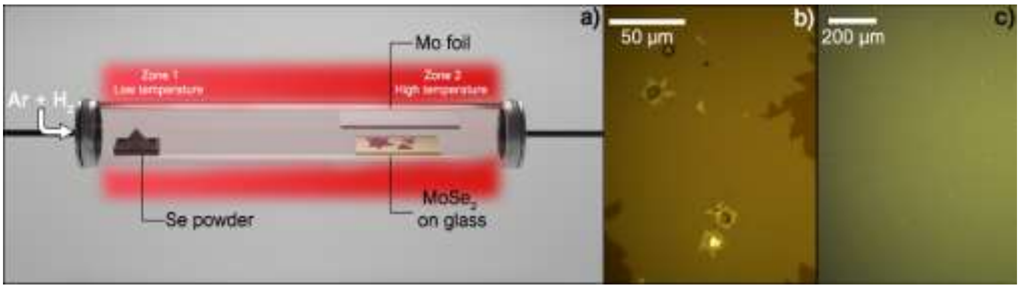

Figure 1: *a) Schematic of the CVD setup for $MoSe_2$ growth;* b*) Optical image of $MoSe_2$ deposited on glass; c) Optical image of CVD-grown hBN continuous film transferred to SiO_2.*