Chemical vapour deposition of monolayer superconducting NbSe$_2$

Hong Wang$^{1,2}$, Xiangwei Huang$^3$, Junhao Lin$^4$, Guangtong Liu$^3$, Zheng Liu$^2$ and Edwin Hang Tong Teo$^1$

$^1$Nanoelectronics Centre of Excellence, School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore 639798, Singapore
$^2$School of Materials Science and Engineering, Nanyang Technological University, Singapore 639798, Singapore
$^3$Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China
$^4$National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba 305-8565, Japan

wong_hong@ntu.edu.sg

The discovery of monolayer superconductors bears consequences for both fundamental physics and device applications. Currently, the growth of superconducting monolayers can only occur under ultrahigh vacuum ($\sim 10^{-10}$ torr) and on specific lattice-matched or dangling bond-free substrates, to minimize environment and substrate induced disorders/defects [1-2]. Such severe growth requirements limit the exploration of novel two-dimensional (2D) superconductivity and related nanodevices. The research presented here demonstrates the growth of monolayer superconducting NbSe$_2$ by salt-assisted ambient-pressure chemical vapour deposition (CVD). Atomic-resolution scanning transmission electron microscope imaging reveals the atomic structure of the intrinsic point defects and grain boundary in monolayer NbSe$_2$, and confirms the low defect concentration in our high-quality film, which is the key to 2D superconductivity. By using monolayer CVD graphene film as protective capping layers, thickness-dependent superconducting properties are observed in as-grown NbSe$_2$ with transition temperature increasing from 1.0 K in monolayer to 4.6 K in 10-layer [3]. The demonstrated method could be applied for growing a large number of highly crystalline 2D transition metal dichalcogenides (TMDs) on substrates [4].

References


Figures

Figure 1: (a) Optical image of uniform NbSe$_2$ crystals deposited on a SiO$_2$/Si substrate. A representative AFM image (inset) shows the typical thickness is 1.1 nm. (b) Temperature dependence of the longitudinal resistance $R_{xx}$ for a monolayer NbSe$_2$ device (upper left inset). Lower right inset: Superconductivity in monolayer, 5-layer and 10-layer NbSe$_2$ devices.