Structural Characterisation of Liquid Phase Exfoliated Transition Metal Dichalcogenides – An Electron Microscopy Study

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Transition Metal Dichalcogenides (TMDs) have risen to popularity due to their range of bandgaps and variety of applications [1]. Platinum diselenide ($PtSe_2$), in particular, has shown many promising characteristics such as high room-temperature mobility, strong layer-dependent band structures and high stability in the air [3,4] presenting opportunities for applications in high-speed sensors and opto-electronic devices [5]. In pursuing novel materials, in-depth characterization is vital and defect studies need to be well established when considering future device applications. In this regard, electron microscopy has shone through as an essential tool in thorough structural and chemical characterisation. In this study $PtSe_2$ was exfoliated through sonic probe Liquid Phase Exfoliation (LPE). Few layer flakes were achieved and subsequently characterized. Flake morphology, point defects and stacking sequences were investigated using various electron microscopy techniques. Transmission electron microscopy (TEM) and Selected Area Electron Diffraction (SAED) was performed using a FEI Titan 80-300 Thermo Fisher Scientific to observe crystal orientation and morphology. Scanning Transmission electron microscopy (STEM) images were recorded with a high angle annular dark-field (HAADF) detector on a Nion Ultra STEM, for atomic resolution structural characterization and point defect analysis. Energy Dispersive X-Ray Spectroscopy (EDS) was used for chemical analysis while Electron Energy Loss Spectroscopy (EELS) allowed for the estimation of the monolayer bandgap.

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[4] G. Wang, et al., *Advanced Materials*, vol. 33, no. 1.(2021)

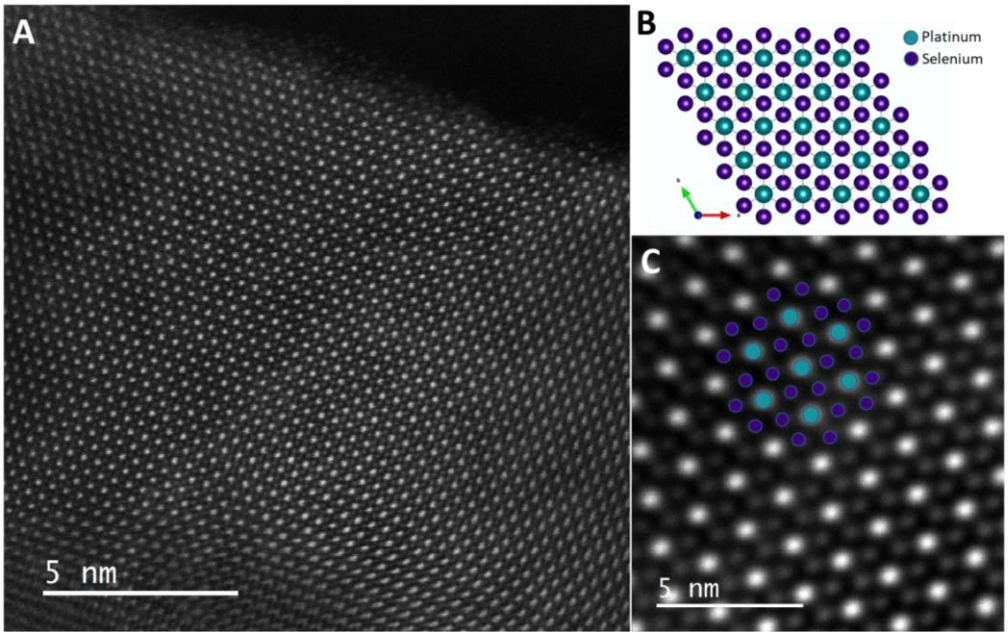

Figure 1: (a) Atomic resolution HAADF image of LPE $PtSe_2$ (b) Model of $PtSe_2$ preferential 1T structure (c) Z-contrast showing clear 1T structure of $PtSe_2$.