**Defects in 2D PdSe2 dendrites as hotspots towards plasmon-free SERS sensing**

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Recently, a new family of two-dimensional (2D) materials, namely noble transition metal di-chalcogenides (NTMDs) with atomic thickness, has received significant attention due to their unique properties, including thickness-dependent tunable-bandgaps that has potential for various optoelectronic applications. PdSe2 is one of the promising NTMDs due to its low symmetry lattice structure with highly tunable bandgap from 0 eV (bulk) to 1.43 eV (monolayer), high carrier mobility, high air stability with monolayer thickness ~0.5 nm. As PdSe2 is very new to the 2D material field, there is no report on the 2D PdSe2 dendrites enriched with intrinsic defects, line defects, nanopores and its exploitation in SERS sensing. To the best of our knowledge, there is no experimental report on intrinsic nanopores in 2D PdSe2 and their applications. In this work, I will present a novel salt solution assisted chemical vapor deposition (CVD) growth yielding bilayer PdSe2 dendrites with controlled dimensions. Our findings highlight the role of intrinsic defects via high-resolution transmission electron microscopy associated with nanopores and line defects in bilayer PdSe2 dendrites generated during the low temperature (280℃) CVD growth process. X-ray electron spectroscopy (XPS) analysis discloses outer and inner layer Se vacancies. A systematic study of atomic-scale defects via high-resolution transmission electron microscopy reveals Se vacancy (VSe) associated with Se-Pd-Se vacancy (VSe-Pd-Se) in monolayer PdSe2, and a series of line defects and nanopores (see Fig. 1) in bilayer PdSe2. The edge geometry of dendrites mainly follows the b-direction Se armchair (Seac), excluding upper layer Se atoms (SeTLU). Our studies reveal that Se vacancy rich PdSe2 gives rise to line defects and edge sites that act as plasmonic hotspots. In PdSe2, topological line defects act as metallic wire, which is responsible for the enhancement in Raman signal. Surface enhanced Raman spectroscopy (SERS) is a very powerful tool for identification of molecular species, but it has been highly relying on the base support of plasmonic nanoparticles (Au, Ag and Cu). It has constantly been debated whether plasmon-free SERS substrate competes with plasmonic SERS substrate. Interestingly, dendritic 2D PdSe2 shows a very high SERS enhancement factor (>105) with ultralow detection limit (see Fig. 1) fills the gap between plasmonic metal based SERS substrate and plasmon-free semiconductor based SERS substrate. The observations, analysis, and related findings presented here show the trivial nature of dendritic PdSe2, which can be expected to replace the existing plasmon-free SERS substrates in high demand in the coming generation and blossom into the affluent area of commercial products.

**Reference:**

1. Jena et. al., npj 2D Materials and Applications (2023) 8



**Figure 1:** SERS enhancement at the dendritic PdSe2.