2D-Layered Amorphous Metal Oxide Gas Sensors (LAMOS): perspectives and gas sensing properties

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The intrinsic thermodynamic instability ($\Delta G < 0$) of 2D exfoliated TMDs/MCs/TMTHs (Transition Metal Dichalcogenides/Metal Chalcogenides/Transition Metal Trihalides), demonstrated by their spontaneous oxidation in dry/wet air laboratory conditions [1], represents a great opportunity to grow, by suitable thermal treatment, template-self-assembled, amorphous-metal-oxides (*a*-MO_x) skin-layers over crystalline 2D exfoliated TMDs/MCs/TMTH.

Departing from liquid phase exfoliated TMDs/MCs/TMTHs, annealing in air at temperatures below the crystallization temperature of the native oxide, either amorphous/crystalline 2D-heterostructures *a*-MO/TMDs [2-3], or fully oxidized amorphous 2D *a*-MO_x interfaces can be prepared [4] with unexploited surface properties.

Herein we demonstrate that the oxidation/amorphization process can be applied to a large variety of exfoliated TMDs (WS_2), MCs ($SnSe_2$) and TMTH ($CrCl_3$) where sulfur, selenium or chlorine atoms can be easily displaced by O_2 atoms under controlled oxidation conditions, producing 2D layered *n*-type *a*-WO_3, *a*-SnO_2 and *p*-type *a*-Cr_2O_3 2D-flakes spin coated as thin film, with excellent sensing properties to H_2, NH_3, H_2S, NO_2 gases and long term stability properties. LAMOS, preserving all the surface to volume advantages of their 2D precursors, open new perspectives for a novel generation of layered amorphous semiconductors with unexplored interaction mechanisms with the environment.

References

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Figures

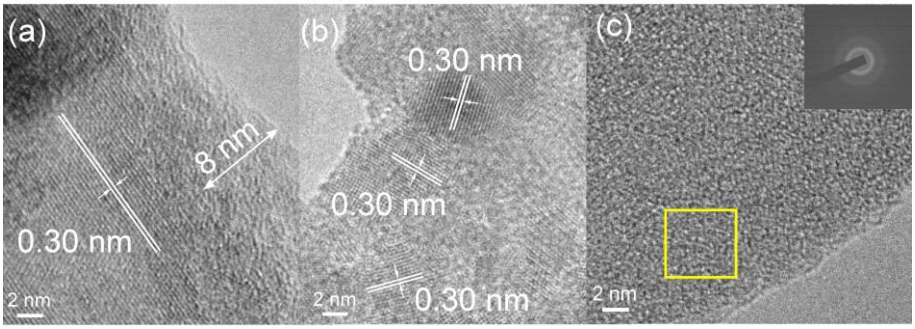

Figure 1: HRTEM pictures of (a) Liquid phase exfoliated $SnSe_2$ flakes displaying the presence of an amorphous oxidized edge (*a*-SnO_2) over crystalline of $SnSe_2$; (b) $SnSe_2$ flakes annealed in air at 250 °C for 1 week displaying a patchwork of amorphous/crystalline *a*-SnO_2/$SnSe_2$ phases; (c) $SnSe_2$ flakes annealed in air at 250 °C for 2 weeks displaying a fully oxidized amorphous 2D *a*-SnO_2 phase (SAED patterns in the inset) [4].