# **Supplementary Information:**

## Evolution of 2D tin oxides on the surface of molten tin

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### **Experimental Methods**

#### **TEM Sample Preparation**

TEM samples were prepared by placing a TEM grid on a PDMS surface and touching this to the molten tin surface, in the same manner as with the  $SiO_2$  substrates used for the other stages of the study. This was necessary to avoid damage to the delicate TEM grids. PDMS was prepared using a previously reported method.<sup>1</sup>

#### Instrumentation

Standard TEM images were obtained using a JEOL 1010 microscope, equipped with a Gatan Orius SC600A CCD camera and operated at an acceleration voltage of 100 keV. HRTEM images were obtained with a JEOL 2100F microscope equipped with a Gatan Orius SC1000 CCD camera and operated at an acceleration voltage of 80 keV. Images were processed and analysed using Digital Micrograph 2.31. X-ray diffraction (XRD) patterns were collected using a Bruker D4 Endeavor with monochromatic Cu K $\alpha$  as radiation source ( $\lambda$ = 0.154 nm). AFM images were obtained using a Bruker Dimension Icon AFM. Images were processed with Gwyddion 2.44. Raman spectroscopy measurements were obtained using a Horiba Scientific LabRAM HR evolution Raman spectrometer with a 50× objective, 1800 mm<sup>-1</sup> grating and a 532 nm laser delivering approximately 4.5 mW to the sample. XPS measurements were taken with a Thermo Scientific K-Alpha XPS spectrometer, with a monochromated AI K $\alpha$  X-ray source with a photon energy of 1486.7 eV and a spot size of 30-400  $\mu$ m.

### **Experimental Results**



**Figure S1:** Normalised XRD spectra of fresh, yellow, pink and grey oxide samples. The fresh oxide shows a single major peak at approximately 29.8°, corresponding to the (101) plane of SnO. The yellow, pink and grey oxides show characteristic SnO<sub>2</sub> peaks at 26.7° and 33.7°, corresponding to the (110) and (101) planes. The yellow oxide also shows a peak at approximately 27.1°, corresponding to reference values for Sn<sub>2</sub>O<sub>3</sub> and Sn<sub>3</sub>O<sub>4</sub>.



**Figure S2:** XPS of tin oxide nanosheets for the (a) Sn3d and (b) O1s spectra. The peaks seen at 495.0 and 486.6 eV in (a), which closely match previously reported spectra. However, stoichiometry cannot be reliably determined in this manner due to the close proximity of SnO and SnO<sub>2</sub> peaks.<sup>2</sup> The two O1s peaks at 533.2 eV and 530.6 eV have been assigned to SiO<sub>2</sub> (the substrate) and SnO, respectively. The separation of these peaks allows for the calculation of an elemental Sn:O ratio of 56:44.

## References

- B. J. Carey, J. Z. Ou, R. M. Clark, K. J. Berean, A. Zavabeti, A. S. R. Chesman, S. P. Russo, D. W. M. Lau, Z.-Q. Xu, Q. Bao, O. Kavehei, B. C. Gibson, M. D. Dickey, R. B. Kaner, T. Daeneke and K. Kalantar-Zadeh, *Nat. Comms.*, 2017, 8, 14482.
- T. Daeneke, P. Atkin, R. Orrell-Trigg, A. Zavabeti, T. Ahmed, S. Walia, M. Liu, Y. Tachibana, M. Javaid, A. D. Greentree, S. P. Russo, R. B. Kaner and K. Kalantar-Zadeh, ACS Nano, 2017, 11, 10974-10983.