Processing, atom-by-atom characterisation and applications of two-dimensional nanosheet inks:

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Liquid phase exfoliation has been proved to be a cheap, scalable method for the mass production of 2D sheets. This talk will first discuss the galaxy of existent layered materials, with emphasis on synthesis, liquid-phase exfoliation, and characterization, focussing on some key applications recently developed in our laboratories, ranging from energy storage to printed electronics. We will for example discuss how two-dimensional Ti3C2 (MXene) can be formulated in aqueous and organic viscous inks for extrusion printing and inkjet printing, respectively, and demonstrate direct MXene printing on various substrates. The additive- and binary solvent-free MXene inks do not show coffee ring effect, enabling high-resolution printing without substrate pre-treatment. The resulting all-MXene printed micro-supercapacitors showcase excellent charge storage performance, including areal capacitance up to 43 mF/cm2 and volumetric capacitance up to 562 F/cm3 in protic gel electrolyte, coupled with long lifetime and good flexibility. We also show examples of all-inkjet-printed MXene arrays for ohmic resistors. The versatile direct-ink-printing technique highlights the promise of MXene functional inks for scalable fabrication of easy-to-integrate components of printable electronics. We will also discuss how MXenes can be used as a conductive binder for silicon electrodes produced by a simple and scalable slurry-casting technique without the need of any other additives. The nanosheets form a continuous metallic network, enable fast charge transport and provide good mechanical reinforcement for the thick electrode (up to 450 μm). Consequently, record high areal capacity anodes (up to 23.3 mAh cm−2) can be demonstrated.