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Large area 2D nanomaterials synthesis utilizing ambient temperature liquid metals

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Two-dimensional materials are widely investigated as the basis for next generation logic devices, optoelectronics and energy storage. [1, 2] A vast variety of 2D materials has been discovered, featuring conductive, semiconducting and insulating properties. Hence 2D materials provide a toolbox that allows creating functional and fully integrated electronic devices based on highly confined electronic systems. The synthesis of large area 2D materials however remains a significant technological challenge.

In this talk a novel synthetic approach utilizing ambient temperature liquid metals will be discussed. Post transition metal alloys containing gallium, indium and tin feature melting points around or below room temperature, providing a liquid metallic reaction environment, while avoiding the use of toxic mercury.[3, 4] Advantageously these liquid metals feature an atomically thin oxide layer on their surface, which constitutes a naturally occurring 2D material. This talk will cover techniques that allow harvesting these 2D oxide layers as 2D nanosheets. Furthermore we will discuss chalcogenization techniques that allow transforming the obtained wide bandgap oxides into narrow bandgap chalcogenide semiconductor sheets. Finally, we will discuss our ongoing work on developing strategies that may allow extending this synthetic approach towards transition metal and lanthanide based materials.

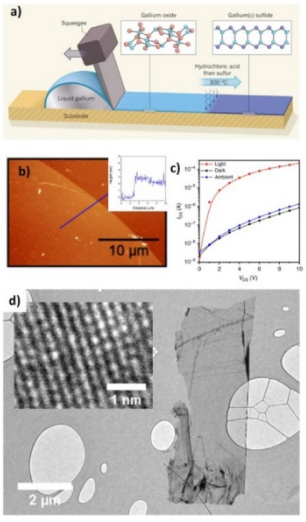

Figure 1: a) GaS liquid metal printing process[4] b) In_2S_3 AFM image c) GaS based photodetector d) TEM image of 2D SnO

References:
[1] High-Performance Field Effect Transistors Using Electronic Inks of 2D Molybdenum Oxide Nanoflakes, Advanced Functional Materials 26, 1, 91–100 (2016)
[2] Two dimensional and layered transition metal oxides, Applied Materials Today 5, 73–89 (2016)
[3] Wafer-scale two-dimensional semiconductors from printed oxide skin of liquid metals, Nature Communications 8, Article number: 14482 (2017)
[4] Materials science: Screen printing of 2D semiconductors, Nature (News & Views) 544, 167–168 (2017)