Two-dimensional materials for next-generation electronics, optoelectronics and antipathogenic coatings

Sumeet Walia[a]

[a] *RMIT University, Melbourne, Australia, VIC 3001, Australia.*

Atomically-thin materials possess unique intrinsic properties and are amenable to a range of tuning techniques. We harness these properties underpinned by application demand and work with industry to translate into end-user products.

Firstly, we synthesise a variety of atomically-thin metal oxides, mono/dichalcogenides and elemental 2D materials using solid, liquid and vapour phase techniques guided by application.

Our fundamental advances have been uncovering the origins of oxidative degradation in few-layer black phosphorus (BP) and subsequently proposing an ionic liquid-based approach to prevent ambient degradation of BP. Using defect engineering, we have demonstrated light operated artificial- synaptic and logic devices and neural networks that can recognise numbers and patterns. We have explored the use of hybrids of dissimilar materials to enhance electronic and optical performance. Ultra-thin layers have been used to develop one of the world's thinnest photodetectors that can sense all shades of light from UV-infrared. We further study strain-tunability in low-dimensional structures via integrating them onto elastomeric platforms.

Lastly, we also deploy these materials as antipathogenic coatings.

Using a cross-disciplinary approach, we deploy multifunctionality of these new material systems into solving technological challenges for a range of industry partners.

References:

1. T. Ahmed, et al "Degradation of black phosphorus is contingent on UV–blue light exposure," Nature Partner Journal: 2D Materials and Applications 18 (2017)
2. S. Walia, et al "Ambient protection of few-layer black phosphorus via sequestration of reactive oxygen species," Advanced Materials 201700152 (2017)
3. T. Ahmed, M. et al "Fully Light-Controlled Memory and Neuromorphic Computation in Layered Black Phosphorus", Advanced Materials, 7, 2004247 (2020)
4. V. Krishnamurthi, et al "Liquid-Metal Synthesized Ultrathin SnS Layers for High-Performance Broadband Photodetectors", Advanced Materials, 32, 2004247 (2020)
5. SK Jain et al "2D/3D Hybrid of MoS2/GaN for a High-Performance Broadband Photodetector," ACS Applied Electronic Materials 3 2407 2021
6. Z. Shaw, et al "Antipathogenic Properties and Applications of Low-dimensional Materials", Nature Communications, 12, 1 (2021)
7. Z. L. Shaw, et al "Broad-Spectrum Solvent-free Layered Black Phosphorus as a Rapid Action Antimicrobial", ACS Applied Materials & Interfaces, 13, 17340 (2021)