Graphene and 2D Materials for Next Generation Opto-Electronics and Photonics

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Graphene is an emerging material for electronics, photonics and optoelectronics due to unique physical properties such as high electrical conductivity, optical transparency and mechanical flexibility. These properties can be further enhanced or tailored to fit specific device functionalities by means of chemical functionalization. A recent example of the potential of chemical functionalization is the intercalation of few-layer-graphene with FeCl3 (dubbed GraphExeter)[1], developed at the Centre for Graphene Science at Exeter. In the past years, our Graphene Centre demonstrated that this material is the best performing carbon-based transparent conductor[1], with resilience to extreme conditions[2] and potential for transparent photo-detectors[3], flexible photovoltaic and organic light emitting devices[4] and foldable light-emitting devices[5]. Among other emerging optoelectronic materials, fluid-dispersed atomically thin 2D nanocomposite materials demonstrate great promise for the next generation of multi-functional optoelectronic systems with a wide range of important applications, such as renewable energy, optical communications, bio-chemical sensing, and security and defence technologies. The most recent highlight in this new research is the first demonstration of 2D materials optofluidic systems- a novel device concept for graphene and 2D materials optoelectronics and integrated photonics[11] developed at the Opto-Electronic Systems Laboratory at the Centre for Graphene Science.

In this talk I will review our latest developments in the use of graphene and functionalized graphene for electronics, photonics and optoelectronics. I will present our recent studies on the use of high quality graphene for next generation light emitting devices and for flexible, wearable touch-sensors[6,7]. I will review our recent demonstration of 2D heterostructures for video-frame-rate imaging applications[8], intelligent design of 2D devices[9] and GraphExeter photodetectors for high-definition sensing and video technologies[10]. I will also present our most recent results on dynamically controlled three-dimensional self-assembly of suspended 2D liquid exfoliated nano-flakes, which provides a breakthrough route for technological realization of 2D material based 3D meta-architectures[11].

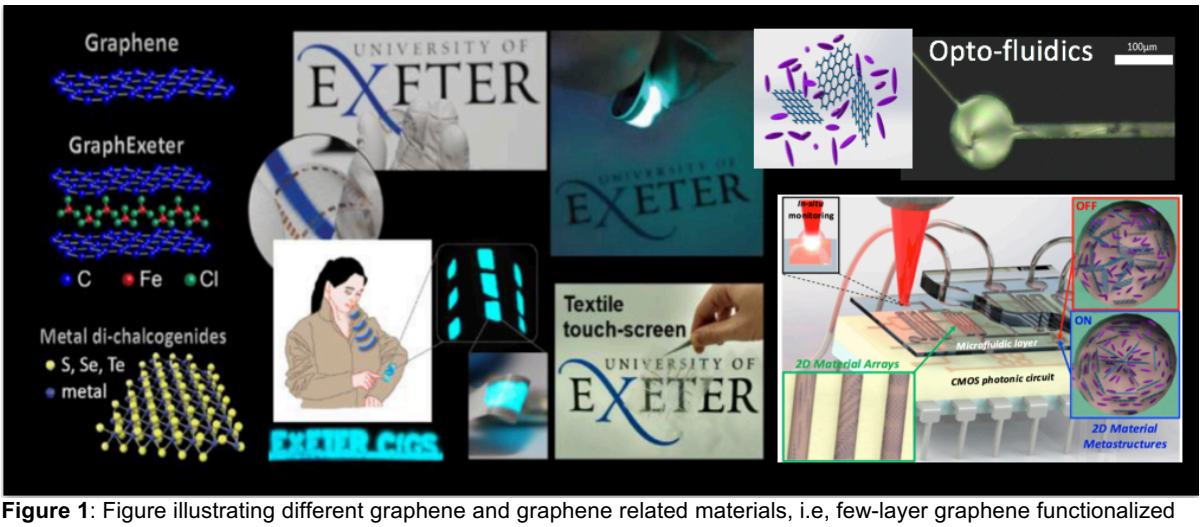

Figure 1: Figure illustrating different graphene and graphene related materials, i.e, few-layer graphene functionalized with FeCl3 and metal di-chalcogenides, and 2D material fluid nanocomposites. These materials are used to build devices for various electronics, optoelectronics and integrated Si photonics applications such as flexible and wearable, transparent touch sensors, foldable light-emitting devices, wearable, textile based light-emitting devices and reconfigurable meta-structures and meta-devices on-chip.

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