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2D material fluid nanocomposites for reconfigurable integrated optoelectronics and Si photonics

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Today, innovation of novel reconfigurable materials, which can be integrated on chip with CMOS compatible process and used for engineering devices, is the key driver for realization of future chip-scale multi-functional systems. Among recently emerged optoelectronic materials the fluid-dispersed atomically thin two-dimensional (2D) nanocomposite materials have sparked a great level of interest for their high promise as *in-situ* tailored meta-material device platform for the next generation of multi-functional (opto)-electronic systems with a wide range of important applications, such as renewable energy, optical communications, bio-chemical sensing, and security and defense technologies. Dynamically controlled three-dimensional self-assembly of suspended 2D liquid exfoliated nano-flakes not only provides a breakthrough route for technological realization of 2D material based 3D device architectures, but also its fluidic nature allows CMOS-compatible back-end integration on chip using microfluidic technology. This opens up almost limitless possibilities in the fabrication of compact and low-power systems for the realization of commercially viable, miniaturized, multi-functional light-management devices, for example light sources, tuneable optical filters and nano-antenna phased arrays. We will demonstrate the possibility to low-power controllable manipulation of 2D nano objects directly on chip utilizing fundamental tuning approaches in Si photonics: electro-optic and thermo-optic effects, as well as discuss the first practicable 2D fluid composite based device designs for application in integrated photonics. We will further focus on the dynamics of 2D nano platelets spatial alignment, understanding of which is essential for the first practicable realization of three-dimensional met structure formation on-chip. Through the optimization of the SOI (silicon-on-insulator) based optofluidic system design to enable simultaneous *in-situ* Raman spectroscopy monitoring of 2D dispersed flakes during the device operation we have successfully demonstrated possibility for the first time a label-free 2D flake detection via selective enhancement of the Stokes Raman signal at given wavelengths. This approach has then been applied to monitor the individual 2D nano platelets in dynamics within a microfluidic channel on chip during application of external stimuli. We discovered ultra-high signal sensitivity to the xyz alignment of 2D flakes within the opto-fluidic channel, which in turn enables precise *in-situ* alignment detection for the first practicable realization of 3D photonic microstructure shaping based on 2D-fluid composites and CMOS photonics platform.

Biography

Anna Baldycheva has completed her BSc from Saint-Petersburg University in 2008 and PhD from the Trinity College Dublin in 2012. She is an Assistant Professor in 2D Optoelectronic Materials at the University of Exeter since 2014, where she is currently leading a highly interdisciplinary research group i.e., Optoelectronic Systems Laboratory. She has extensive expertise in the design, fabrication and testing of integrated Si micro-photonic systems. Since 2011, she has over 50 peer-reviewed publications, invited talks and conference proceedings. She is an Associate Editor of the *Nature Scientific Reports* and is serving on Board of the Royal Microscopy Society Engineering Section.

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