Three-dimensional, Corrugated Graphene Micro-/Nano-Structures for Advanced Sensor Devices

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Abstract

Superb electromechanical properties of two-dimensional (2D) materials provide a substantial promise for advanced nanoelectromechanical devices, flexible electronics, and wearable bioelectronic devices. In this talk, I present my group's work on fabrication and processing of crumpled 2D materials-based micro-/nano-structures for advanced optoelectronic and bioelectronic sensors. First, I introduce monolithic synthesis of graphene-graphite for flexible, all-carbon transistor arrays. We demonstrate all-carbon device arrays integrated with various soft and flexible surfaces, including wearable contact lens, for wearable electronics applications. Second, I present a rapid and scalable method of creating crumpled graphene and MoS_2 monolayer surfaces by soft-matter transformation of shape-memory polymers as well as swelling-induced integration processes. Third, we further explore optoelectronic applications of crumpled graphene structures by developing mechanically reconfigurable optoelectronic sensors with ca. 500% improved photo-responsivity compared to conventional graphene optoelectronic sensors. Finally, we explore biosensor device applications by constructing an array of field-effect biosensors and interfacing them with muscle and cardiac cells for nano-electrophysiology. I believe our approach to forming crumpled 2D materials-based micro-/nano-structures offers a unique avenue for creating multifunctional sensors, and furthermore, these capabilities could be applied to advanced optoelectronics as well as wearable and conformal electronics in the near future.