Nanofluidics and 2D Materials-Based Nanosensors.

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In this talk I will discuss various detection schemes using both electrical and ionic currents modulation through precisely engineered nanostructures which includes different nanofluidic elements (ionic current measurement) and two dimensional (2D) materials (electrical current measurement). Giving enormously high surface to volume ratios, such structures offer high detection limits and large dynamic ranges for building superior sensors.

Nanofluidics can be defined as the field of studying mass transport phenomena (usually in a liquid phase) in objects with the characteristic dimensions less than 100nm. At such dimensions, the surface to volume ratio increases dramatically compared to channels with micrometer size and allows controlling the ion and molecule flow through the nanochannels directly, without flux of the whole solution. Ions and molecules cannot avoid interactions with the nanochannel interior walls at such small dimensions. By controlling these interactions one can dictate the type and flux of ions/molecules passing through the nanochannel and thus build new types of sensors.

In the first part of the talk I will discuss applications of nanopores and nanochannels in various sensing nanofluidics approaches for detection of variety of biomolecules. Ionic transport through nanopores and ion channels in cell membranes exists in virtually all biological cells and is important in in many phenomena such as the regulation of heart function, nerve signals, and delivery of nutrients to the cell. Nanopores have also started to play a major role in contemporary biotechnology, because many separation and sensing processes require pores with nanometer-sized openings. The examples of nanosensors for detection of specific DNA and anthrax will be given. These emerging sensors are based on local changes of the surface charge on walls of nanochannels induced by binding of an analyte. The specific analyte binding is detected as a change of the ion-current rectification of single nanopores defined as a ratio of currents for voltages of one polarity, and currents for voltages of the opposite polarity.

In the second part of the presentation, I will discuss versatile nanosensors based on emerging 2D materials – such as graphene and MoS_2. 2D materials have the highest surface to volume ratio and thus represent attractive platform for various types of sensors. Various gas nanosensors with ultra-low detections limits will be presented.