Analogue Ionically-Coupled Multi-Terminal Memristors Based on Plasma-Treated MoS_2 Layers

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Abstract: Memristors have been extensively studied as important components for constructing artificial neural networks for neuromorphic computing applications. The current memristor-based neural networks based on transition metal oxides are still mainly driven by electronic effects (*e.g.*, voltage distributions), while ionic-interactions, as observed in biological networks, could effectively reduce the power consumption of neural networks and also result in a higher analogue computation precision. To emulate such sophisticated interactions, including synaptic competition and cooperation, ionically-coupled multi-terminal memristors are needed. Recently, memristors based on 2D semiconductors (*e.g.*, MoS_2 and WSe_2) were demonstrated. Such 2D semiconductor memristors exhibit low threshold fields for initiating memristive switching and analogue switching characteristics. The memristive switching behavior of such memristors has been attributed to multiple mechanisms. One of these mechanisms is the interaction between movable ionic defects in 2D semiconductor layers and the Schottky Barriers at semiconductor/metal interfaces.[4] This mechanism could be further employed to produce ionically-coupled memristors. Therefore, it is highly desirable to develop materials processing and fabrication approaches capable of generating a high areal density of movable ionic defects in 2D semiconductor layers. Here, we report that a plasma treatment can form a high density of movable S vacancies in few-layer MoS_2 layers (Fig. 1 (a)). The memristors made of such plasma-treated MoS_2 layers exhibit analogue pulse-programmed switching characteristics with a good linearity in switching courses. In addition, multiple such memristor channels can be ionically coupled and could be further exploited for emulating complex synaptic interactions in biological systems. This work leveraged the unique in-plane transport properties of 2D layered semiconductors for memristive electronics applications and advanced the nanofabrication capability for controlling memristive switching behaviors.

Biography: Dr. Xiaogan Liang is currently working as an Associate Professor at The Mechanical Engineering Department of University of Michigan (UM). Before joining UM, Dr. Liang was a Staff Scientist working at The Molecular Foundry, Lawrence Berkeley National Laboratory. His current research interests are focused on nanofabrication, nanomanufacturing and microsystem integration, nanoelectronics and optoelectronics based on low-dimensional nanostructures, biosensors, and flyer/microdrone sensors. Dr. Liang has coauthored 69 journal publications and >50 conference presentations, has given >30 invited presentations, and has 8 US patents. Dr. Liang is the recipient of NSF CAREER Award, and he is the member of Sigma Xi, IEEE, and ASME. Dr. Liang obtained a BS in Physics from Peking University, a MS in Condensed Matter Physics from Institute of Semiconductors, Chinese Academy of Sciences, and a Ph.D. in Electrical Engineering from Princeton University.