Two-dimensional materials for on-chip micro-supercapacitor

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Revolutionary two-dimensional (2D) materials have opened a wide avenue of new applications, including energy storage. Nanomaterials have so far played a vital role in the development of micro-supercapacitors; however, available fabrication methods have limited the size of planar micro-supercapacitors to the millimetre scale only. In this talk, I will highlight the research in my group on exploiting the properties of 2D materials to develop an on-chip supercapacitor with unprecedented energy storage capability. The field effect transistors (FET) are used as novel electrodes for a gate-tunable density of states in 2D semiconductors. Molybdenum disulfide (MoS_2) and graphene interfaces are used to fabricate a symmetric micro-supercapacitor on Si/SiO_2 substrate for an on-chip device. Back-gate bias-controlled electric double-layer enhances ion interaction at both edges and interlayers of MoS_2, thereby increasing the electrochemical capacitance by three orders of magnitude. We also used carbon nanotubes (CNTs) to investigate the effect of alignment on the formation of an efficient network in a planar supercapacitor. A notable difference is observed in the optimal alignment of the CNTs between the electrodes.

1. On-chip Micro-supercapacitor of Aligned CNT/MnO_2, Materials Today Communications, 50, 114350, 2026.
2. Gate Field Induced Extraordinary Energy Storage in MoS_2-Graphene-Based Ultramicro-Electrochemical Capacitor, ACS Energy Lett. 2023, 8, 3, 1510–1519.