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Rational Design of Nanostructured and Functionalized Graphene and Their Applications for Electronics and Energy Devices

2D materials, including graphene and MoS_2 and phosphorene, have attracted intensive interests due to their unique chemical and physical properties. These tremendous features make them as promising candidates for applications on nano-electronics, sensors, and energy storage. In this talk, three main related topics will be conducted: (1) The current developed approaches for the synthesis of 2D materials, such as Spiral-CVD graphene, printed MoS_2-nano-ribbon, and phosphorene. [1-7] In particularly, the proof-of-concept on phosphorene-based RRAM device was demonstrated with reliable and superior performance, such as high on/off current ratio of ~10^5 and stable retention >10^4 s. [8] (2) We demonstrate an all screen-printable solid-state micro-supercapacitor(MSCs), which was integrated with graphene/CNTs as hierarchical electrodes. It exhibits a high cycling stability after 1000 cycles and excellent mechanical flexibility. The extracted energy and power density of 16.4 mWh/cm^3 and 294.8 W/cm^3, which was, to our best knowledge, the highest performance for ultra-thin(<5 um) MSCs. This work provides a scalable and cost-effective method to produce solid-state MSCs with high energy density. (3) Fluorinated graphene has been synthesized by various approaches; however, most of the processes using toxic chemicals with complex steps, which hinder the practical applications. Here, we report a novel hydrothermal method for fabricating FG through frequently used Nafion as reagents. The FG coated substrate shows high hydrophobic property, where the contact angle (water) of above 120^o was achieved. Finally, the composite film with FG(0.75 wt%) as an additive in epoxy shows excellent anticorrosion ability with corrosion rate at 2.9x10^{-5} mm/year, which was ~200% enhanced if compare it with pristine epoxy. This work proposed a one-pot and green process for preparing FG in a scalable way, which is potential for applications in the sustainable environment in the future.

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