A Novel Fabrication of 3.6nm High Graphene Nanochannels for Ultrafast Ion Transport

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Fluidic nanochannels have presented the possibility as an outstanding molecular sieve due to the fast and selective transport of water, gas, and ions[1]. Theoretical studies predicted that the hydrophobic nanochannel could transport water and gas much faster, but the experimental studies in nanochannel are rarely explored. Here, we fabricate graphene-based 2D nanochannels with rectangular shapes, for the first time, of 3.6, 10, and 50 nm heights and a 2 µm width, and report their ion transport properties.

We fabricated the 3.6 nm high, rectangular graphene nanochannels in which the water solution flows along the graphitic surface for the first time to study the ion transports in these nanochannels. The fabrication options of nanochannel inscription and the novel technique of graphene conformal coating altogether enabled us to create graphitic nanoconfinements with no limitation to particular nanomaterials, such as carbon nanotube, thereby leading to diversified investigation of the unique nanofluidic phenomena in the graphitic environment.

Under the electric field to transport the ions, the 3.6 nm graphene nanochannel conducts ions 115 times faster than the nanochannel without graphene in a deionized (DI) water solution, also yielding similar results using other electrolytes. The prepared 3.6 nm high graphene nanochannels take a clean and smooth surface and show ionic conductance ≈115 times larger than that in the $SiO2/Si$ nanochannels (with larger nanochannels with 10–50 nm heights showing significantly less enhancements). Detailed mechanistic understanding remains to be further investigated. These graphene-based artificial nanochannels promise to offer new opportunities for applications such as fast desalination, ion field effect transistors, and energy harvesting and storage in its nanofluidic confinement.

References

[1] M. Majumder, N. Chopra, R. Andrews, B. J. Hinds, "Multi-DOF Counterbalance Robot Arm based on Slider-Crank Mechanism and Bevel Gear Units," *Science*, 438, pp.44, 2005.

[2] W. Jung, J. Kim, S. Kim, H. G. Park, Y. Jung, C.-S. Han, *Advanced Materials*, 1605854, 2017.

Figures

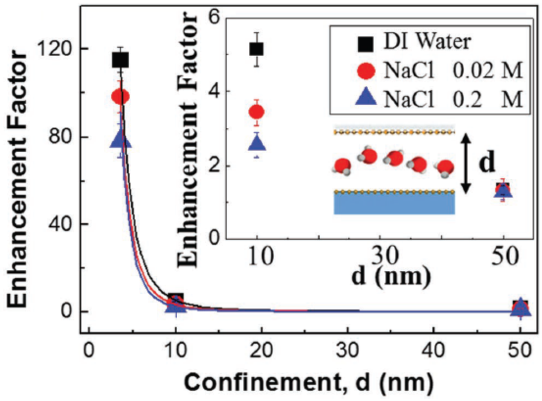

Figure 1. Flow enhancement factors of graphene-based nanochannels compared with SiO2/Si nanochannels. Inset figure shows the enlargement of the enhancement factors of 10 and 50 nm channels.

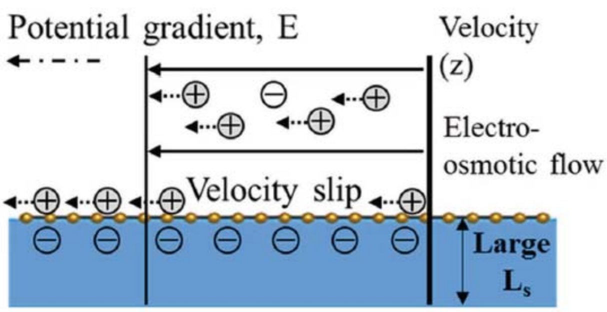

Figure 2. Concept illustrations of the enhanced electroosmotic flow in graphene-based 3.6 nm channels having a high hydrophobicity, large slip length, and nanoconfined properties.