Electrical property degradation of graphene FET by water diffusion beneath graphene channels

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Abstract

Despite of being discovered as a perfect 2 dimensional material with a high carrier mobility which stems from the linear energy-momentum dispersion in a low energy level[1, 2], many engineers casted doubt on using graphene in modern sciences since its size realized on silicon dioxide substrate had been too small to apply conventional semiconductor fabrication for mass production. Afterward a technique of making a wafer size large area graphene was developed by using chemical vapor deposition method.[3] There are still, however, obstacles when transferring it to certain substrates in terms of residue, adhesion and ripples.[4-6] Most of all, electrical property degradations such as the charge inhomogeneity caused by electron-hole puddles[7] and the partial doping which is usually found to be a p-type are introduced by water even in ambient condition.[8] There is an experimental paper regarding its physical property alterations by using atomic force microscopy when water diffuses in between graphene and substrate though the edges or defects of the exfoliated graphene sheets.[9] Judging from this paper, we expect there are also similar changes in electrical properties of graphene based devices under uses of water. Graphene FET devices with three terminals (source, drain and gate) of which channel widths and lengths are fixed at 2 um and ranging from 5 to 50 um, respectively, were fabricated. We placed them in a thermo-hygrostat making its condition 80% relative humidity under 70 degrees Celsius at most. In relatively high humidity condition, water diffuses faster than usual, and it shows clear results in instabilities of electrical property.

Therefore, not only for making reliable graphene devices under water permeation but also for applications of them performing in water, for example, humidity sensors, we need to enhance the adhesion between graphene and substrate or develop improved passivation techniques.

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