Improved ion sensing graphene field effect transistors using ultra-thin parylene encapsulation

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Abstract

Graphene field effect transistors (FETs) are an attractive candidate for sensing applications because of their high charge carrier mobility and the ideal coupling between graphene charge carriers and surface potential. However, depositing a selective layer on the graphene for these sensing applications can degrade graphene's electrical properties, increase hysteresis, and present a challenge for maintaining its stability and performance. Here, we protect the graphene by encapsulating it with an ultrathin layer (~ 4nm) of parylene, a hydrophobic polymer, and then deposit a ~ 3nm aluminum oxide sensing layer to characterize large are graphene ion sensitive field effect transistors (ISFETs). Not only do we demonstrate pH sensitivities approaching aluminum oxide's limit of ~ 48 mV/pH [1] over pH 2.5 through pH 7.5, but we also observe significant improvements in field effect mobilities of ~ 7000 $cm^2V^{-1}s^{-1}$ and in transconductance with limited hysteresis compared to previous work [2]. The observed improvements due to the graphene encapsulation has resulted in the substantial improvement in the minimum detection limit of our ISFETs to 5 mpH/ rtHz, advantageous to highly sensitive applications.

References

[1] R.E.G. van Hal, J.C.T. Eijkel, P. Bergveld, Advances in Colloid and Interface Science, **69** (1996) 31-62.
[2] I. Fakih, S. Sabri, F. Mahvash, M. Nannini, M. Siaj, T. Szkopek, Applied Physics Letters, **105** (2014) 083101.

Figures

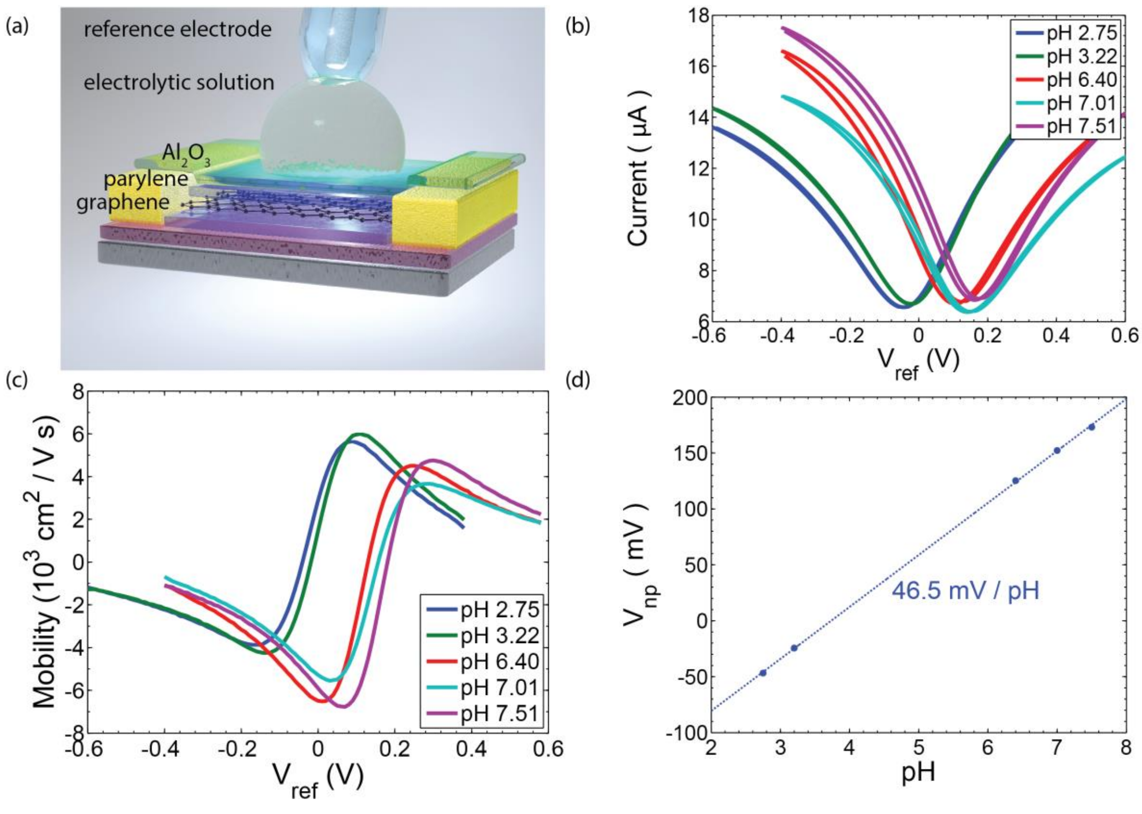

Figure 1:(a) Schematic of a graphene based ISFET encapsulated with parylene with Al_2O_3 as a sensing layer. (b) The current flowing through the graphene channel while sweeping the reference electrode voltage V_{ref} in both directions with different pH buffer solutions. (c) The field effect mobility of the carriers versus the reference electrode voltage V_{ref} for different pH buffer solutions. (d) The neutrality point potential of the minimum conductance V_{np} for the different pH buffer solutions; a 46.5 mV/pH sensitivity is observed.