Albert F Rigosi
Mattias Kruskopf, Heather M. Hill, Hanbyul Jin, Bi-Yi Wu, Philip E. Johnson, Siyuan Zhang, Michael Berilla, Angela R. Hight Walker, Christina A. Hacker, David B. Newell, and Randolph E. Elmquist
Physical Measurement Laboratory, National Institute of Standards and Technology (NIST), Gaithersburg, MD 20899, United States

albert.rigosi@nist.gov

Gateless carrier density tunability in epitaxial graphene devices functionalized with chromium tricarbonyl

Monolayer epitaxial graphene (EG) has been shown to have clearly superior properties for the development of quantized Hall resistance (QHR) standards. One major difficulty with QHR devices based on EG is that their electrical properties drift slowly over time if the device is stored in air due to adsorption of atmospheric molecular dopants. The crucial parameter for device stability is the charge carrier density, which determines the energy spacing of the Landau levels and thus the magnetic flux density required for precise QHR measurements. This work presents one solution to this problem of instability in air by functionalizing the surface of EG devices with chromium tricarbonyl - $Cr(CO)_3$ [1]. Observations of carrier density stability in air over the course of one year are reported, as well as the ability to tune the carrier density by annealing the devices. For low temperature annealing (< 360 K), the presence of $Cr(CO)_3$ stabilizes the electrical properties and allows for the reversible tuning of the carrier density in millimeter-scale graphene devices close to the Dirac point. Precision measurements in the quantum Hall regime show no detrimental effect on the carrier mobility.

References

[1] E. Bekyarova, S. Sarkar, S. Niyogi, M.E. Itkis, and R.C. Haddon. J. Phys. D: Appl. Phys., 45 (2012), pp. 154009-1–154009-18.

Figures

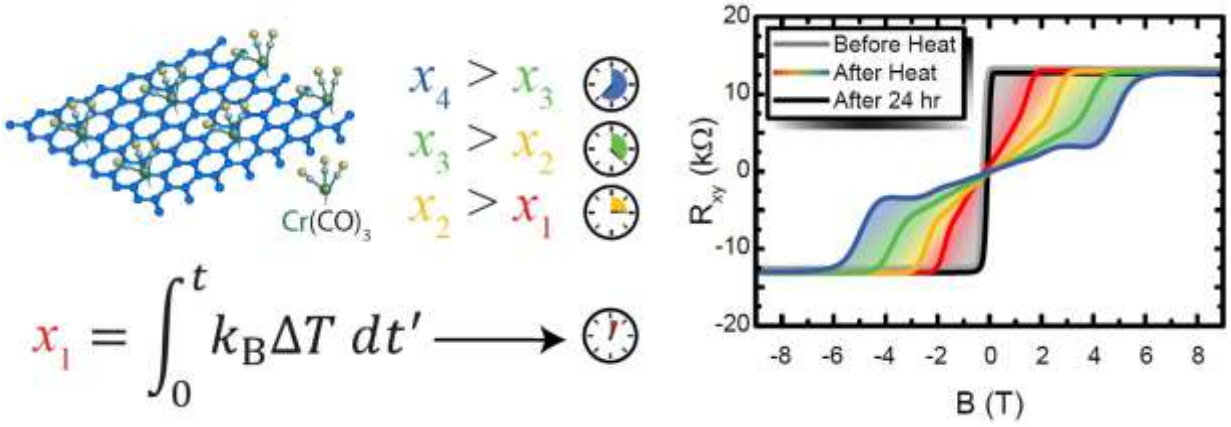

Figure 1: Rendering of the graphene crystal structure is shown functionalized with $Cr(CO)_3$. The Hall resistance indicates the increase of the electron density based on the amount of integrated heat exposure. In all cases following application of heat, the device is left in air for a period of at least one day, the device's carrier density returns to a value on the order of 10^{10} cm^{-2}.