Doping Graphene With Substitutional Manganese Atoms

Pin-Cheng Lin[1]
Renan Villarreal[1], Harsh Bana[1], Goele Magchiels[1], Maya N. Nair[2], Ken Verguts[3,4], Steven Brems[4], Stefan de Gendt[3,4], Simona Achilli[5], Guido Fratesi[5], Manuel Auge[6], Felix Junge[6], Hans Hofsäss[6], Chris Van Haesendonck[1], Lino M. C. Pereira[1]
[1]*Quantum Solid-State Physics, KU Leuven, 3001 Leuven, Belgium,*
[2]*CUNY Advanced Science Research Centre, 85 St. Nicholas Terrace, New York, N.Y. 10031, USA*
[3]*Departement Chemie, KU Leuven, 3001 Leuven, Belgium,*
[4]*Interuniversitair Micro-electronica Centrum (imec), vzw, 3001 Leuven, Belgium,*
[5]*ETSF and Dipartimento di Fisica, Università degli Studi di Milano, Via Celoria, 16, I-20133 Milano, Italy,*
[6]*II. Institute of Physics, University of Göttingen, Göttingen 37077, Germany,*
pincheng.lin@kuleuven.be

Functionalization of 2D materials generally requires the modification of their physicochemical properties. Several approaches have been explored: the use of different substrates, creation of intrinsic defects (e.g. vacancies), adsorption and intercalation (of atoms, clusters or molecules), substitutional doping, among others. For incorporation of substitutional dopants, despite the numerous approaches that have been investigated, a major challenge remains: the limited control over the concentration and form of incorporation. An alternative approach is to incorporate the foreign species by ultra-low energy (ULE) ion implantation, precisely tuning the number of implanted ions and their kinetic energy [1]. Here, we demonstrate that it is possible to controllably incorporate manganese (Mn) in graphene as a substitutional graphitic dopant using ULE ion implantation. Our approach is based on a wide range of characterization techniques (structural, electronic, and magnetic), including scanning tunneling microscopy and spectroscopy (STM/STS), synchrotron-based X-ray photoelectron spectroscopy (XPS), angle-resolved photoemission spectroscopy (ARPES), X-ray magnetic circular dichroism (XMCD), transport measurements, Raman spectroscopy, among others. These experimental studies are complemented by density functional theory (DFT) calculations. The new insights provided by our work establish a framework for the controlled incorporation of magnetic dopants in graphene and other 2D materials, using ULE ion implantation.

References

[1] P. Willke *et al.*, Appl. Phys. Lett. 105, (2014), 111605

Figures

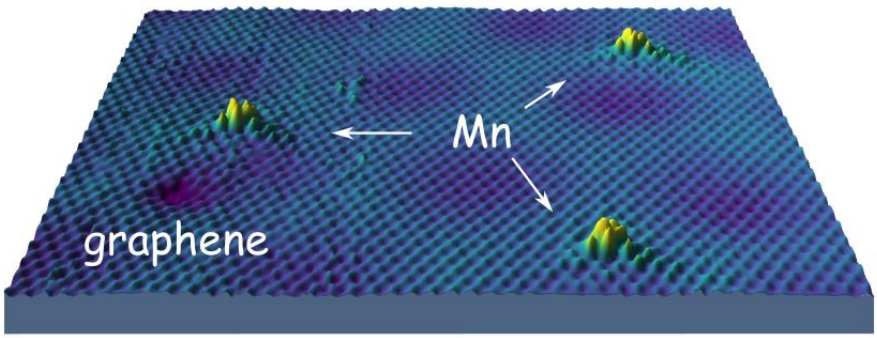

Figure 1: STM image of graphene with substitutional Mn atoms incorporated by ultra-low energy ion implantation.