User-friendly graphene-based quantum resistance standards

W. Poirier[1], F. Lafont[1], R. Ribeiro-Palau[1], D. Kazazis[2], A. Michon[3], B. Jouault[4], O. Couturaud[4], C. Consejo[4], M. Zielinski[5], Th. Chassagne[5], M. Portail[3], B. Jouault[4], F. Schopfer[1]

[1]Laboratoire National de Métrologie et d'Essais, Trappes, 78190, France
[2]Laboratoire de Photonique et Nanostructures, CNRS, Marcoussis, 91460, FRANCE
[3]CRHEA, CNRS, Valbonne, 06560, FRANCE
[4]Laboratoire Charles Coulomb, Université de Montpellier 2, CNRS, Montpellier, 34095, FRANCE
[5]NOVASiC, Le Bourget du Lac, 73370, FRANCE

wilfrid.poirier@lne.fr

The quantum Hall effect (QHE) provides a universal standard of electrical resistance in terms of the Planck constant h and the electron charge e. One hallmark of the graphene Dirac physics is a unique QHE which is exceptionally robust. An ongoing goal of metrologists is to use this advantage to develop graphene-based quantum resistance standards (G-QHRS) operating in more convenient experimental conditions than the usual standards made of GaAs/AlGaAs heterostructures which operate at high magnetic fields (B~10 T), low temperatures (T~1.3 K) and currents (I~40 μA). This would reduce the operating cost of the ohm maintaining in national metrology institutes and would improve the dissemination towards industrial end-users. Although the 10^{-9} accuracy of the quantized Hall resistance (QHR) on the ν=2 plateau (ν is the Landau level filling factor) was demonstrated in a few graphene devices [1], this was obtained at still high and not competitive operating magnetic fields up to now.

We will present measurements of the QHR on the ν=2 plateau carried out in large (100 × 420 μm^2) Hall bars based on graphene grown by chemical vapor deposition of propane under hydrogen on the Si-face of SiC substrates, a hybrid scalable growth technique recently developed [2]. Fig. 1 demonstrates the 10^{-9} accuracy of the QHR (R_H) over an exceptionally wide range of magnetic fields from B = 10 T in a device that can therefore operate, for the first time, in cryomagnetic conditions similar to those of GaAs-QHRS [3]. Achieving lower carrier density (down to $2x10^{11}cm^{-2}$) and higher carrier mobilities (up to 9000 $cm^2V^{-1}s^{-1}$) graphene, we recently showed that a G-QHRS can outperform GaAs-QHRS and operate with an accuracy of $1×10^{-9}$ in experimental conditions unattainable to any usual semiconductors: B as low as 3.5 T, T as high as 5.1 K, and I up to 280 μA. This is a breakthrough in the resistance metrology application since it opens the era of user-friendly helium-free quantum resistance standards able to be widely disseminated.

[1] T. J. B. M Janssen et al, Metrologia **49** (2012), 294.
[2] A. Michon *et al.*, Appl.Phys. Lett. **97** (2010), 171909.
[3] F. Lafont *et al.* arXiv:1407.3615 (2014).

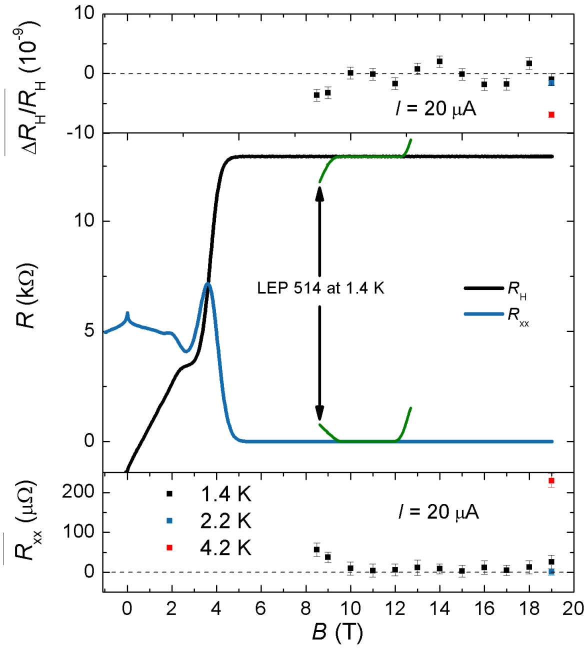

Fig.1: a) Relative deviation of the Hall resistance to the quantized value $\Delta R_H/R_H$ *versus* magnetic field B. b) Hall resistance R_H and longitudinal resistance R_{xx} *versus* B (in green for GaAs sample). c) Accurate measurements of the longitudinal resistance R_{xx} *versus* B.