CYCLOTRON RESONANCE OF MULTI-LAYER EPITAXIAL GRAPHENE UNDER VERY HIGH MAGNETIC FIELD

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Recent infrared spectroscopy measurements on epitaxial graphene have confirmed the square-root dependence of various intra- and interband transitions with respect to an external magnetic field. So far, these measurements have not included an extended study of the fundamental cylcotron resonance which is obscured by the opacity of the SiC substrate in the relevant energy range. Here we present first results obtained with a CO-laser while using semi-destructive magnetic fields up to 120 T generated with a single-turn-coil.

In this contribution, we present a detailed discussion of the temperature and radiation energy dependence of the observed transition. A schematic drawing of the setup is shown in figure 1. The investigated sample was prepared on a 4H SiC substrate (C-face), grown in vacuum by thermal decomposition [1,2]. It contains around 70-100 decoupled graphene layers confirmed by Raman measurements [3]. The light source is a tunable CO-laser providing radiation between 5.2 μm to 6 μm (238 meV to 207 meV) with a maximum output power of 2 W. Figure 2 shows experimental datas, obtained at 229 meV and room temperature, which exhibit two prominent features :

a)The absorption peaks marked by black arrows correspond to the cyclotron resonance of graphene, the energy transition from the zeroth to the first Landau level. The position of absorption lines has a square-root dependance with the magnetic field. The measured Fermi velocity is in good agreement with previous measurements [4-6].
b)One broad additional absorption line, marked by gray arrows, around 100 Tesla is observed. There is no theoretical predicted transition for single-layer graphene at this magnetic field and this energy excitation.

Additionally, the production of field over 100 Tesla induces some phenomena cause by the high time field derivative. These effects will be presented with the description of the Megagauss generator.

In conclusion, these preliminary results are now precisely investigating to probe any deviation of the first Landau Level from the square-root dependency and further experiments on the unknown absorption will clarify its origin. With increasing the magnetic field, some others unseen effects such as valley and spin splitting, and intraband transitions could be observed.

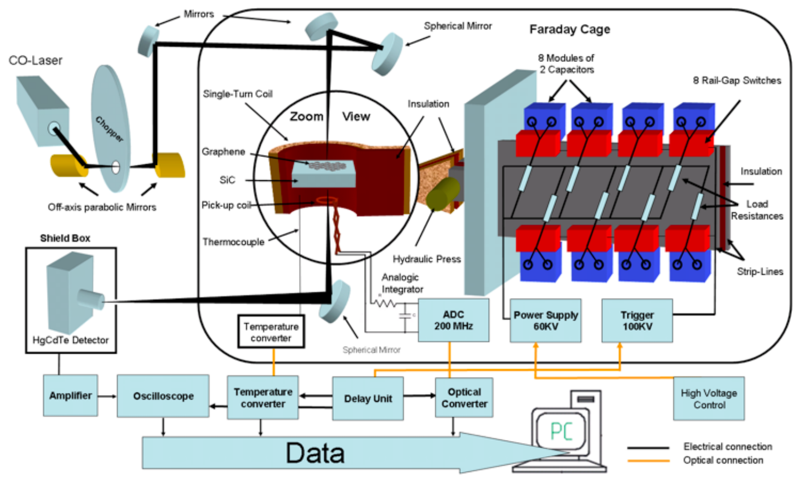

Figure 1: Experimental set-up for cyclotron resonance measurements over 100 Tesla. Right part shows the Megagauss generator with the capacitor bank and trigger components. Left part describe the lightpath. Zoom view is a sectional view of the single-turn-coil. Bottom part shows the acquisition scheme.

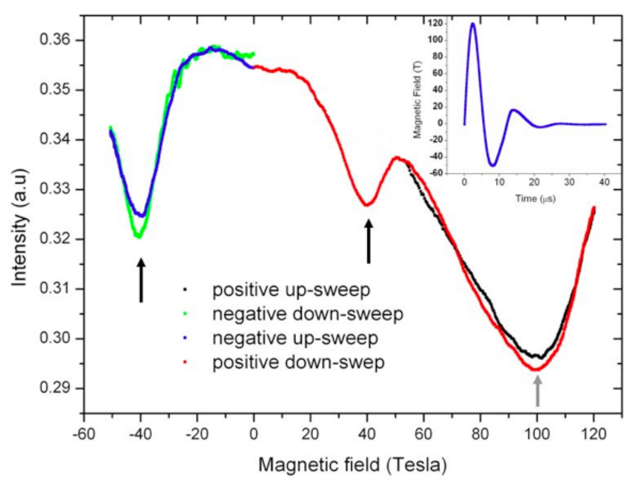

Figure 2: Transmission of multi-layered epitaxial graphene grown on Si-C. The incident energy is 229 meV. The magnetic field as a function of time is plotted in the inset. Black arrows are the absorption for the fundamental Landau level transition and gray arrows are an additional observed absorption.

References

[1] C. Berger et al, J. Phys. Chem, 108, 19912 (2004).
[2] C. Berger et al, Science. 312, 1191 (2006).
[3] C. Faugeras et al, Appl. Phys. Lett. 92, 011914 (2008).
[4] M.L. Sadowski et al, Solid State Comm. 143, 123-125 (2007).
[5] P. Plochocka et al, Physical Review Letters. 100, 087401 (2008).
[6] N. Ubrig et al (in progress).