CVD-graphene growth and automated transfer for large-area, high performance applications

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Abstract

Due to its large area and excellent electrical properties, CVD graphene is a suitable nanomaterial for electromagnetic insulation (EMI) [1], for communications as FET transistors for RF [2], and for THz/IR applications [3] such as antennas or plasmonics, among others. Still, its main disadvantage is the need of transferring the graphene layer from the metal catalyst to a suitable final substrate. A manual transfer method [4] was developed to overcome this issue. It consists of protecting the graphene with a thin polymer layer, wet-etching the growth substrate, rinsing with deionized water, and finally depositing the resulting polymer/graphene membrane onto the desired target substrate. Despite this method has been strongly optimized [5, 6], it still requires strong handling skills, is time consuming, and is not suitable for an industrial process. An alternative method based on a roll-to-roll system [7] can overcome some limitations of the manual method, but it is limited to flexible substrates.

In this work we report on the CVD growth of large-area graphene using a cold wall reactor (Fig. 1), and a lab-scale system designed to transfer graphene automatically to arbitrary substrates, which could be easily scaled up for industrial applications. The system is composed of several modules that control the process temperature, the liquid flow and the overall system state. An Arduino UNO microcontroller is used as the real-time control system, timing and activating the rest of modules. It also allows communication with a computer for logging purposes. The passive components of the system are depicted in Fig. 2. A polytetrafluoroethylene (PTFE) tube encloses the graphene sample during the whole process. This enclosing tube has a surface treatment that centers the polymer/graphene membrane that floats inside it. The treatment avoids mechanical stress or induced ripples in the graphene during the process. A fixed platform and a substrate holder ensure a fixed position between the final substrate and the tube center. All these pieces are immersed into a liquid, starting with an etchant solution and changing gradually into deionized water for the final rinsing steps.

Finally, graphene field-effect transistors (GFETs) were processed on the same CVD material but transferred using both the standard manual method and the novel automatic method for comparison. Raman and electrical assessment of the GFETs using a theoretical model [8] demonstrate that devices on the automatically-transferred graphene present systematically higher mobilities and less impurity contamination (Fig. 3).

Acknowledgements

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References

[1] Seul Ki Hong, Ki Yeong Kim et al., Nanotechnology, vol. **23**, **45** (2012), p. 455704.
[2] Frank Schwierz, Nat. Mater., vol. **5**, **7** (2010), p. 487.
[3] Tony Low, Phaedon Avouris, ACS Nano, vol. **8**, **2** (2014), p. 1086.
[4] Alfonso Reina, Xiaoting Jia et al., Nano Lett., vol. **9**, **1** (2009), p. 30.
[5] Wei-Hsiang Lin, Ting-Hui Chen et al., ACS Nano, vol. **8**, **2** (2014), p. 1784.
[6] Hai Li, Jumiati Wu et al., ACS Nano, vol. **8**, **7** (2014), p. 6563.
[7] Sukang Bae, Hyeongkeun Ri Kim et al., Nat. Nanotechnol., vol. **5**, **August** (2010), p. 574
[8] Alberto Boscá, Jorge Pedrós et al., J. Appl. Phys., vol. **117** (2015), p. 044504

Figures

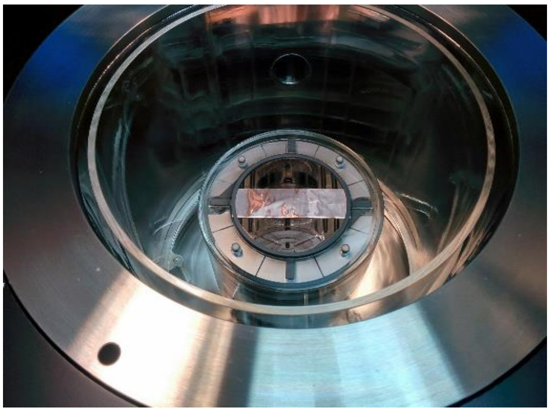

Figure 1: CVD system chamber for 4” wafer graphene growth.

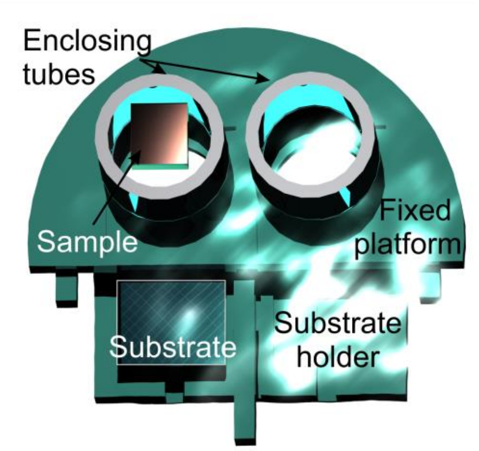

Figure 2: PTFE passive components (in liquid) and the sample and final substrate positions

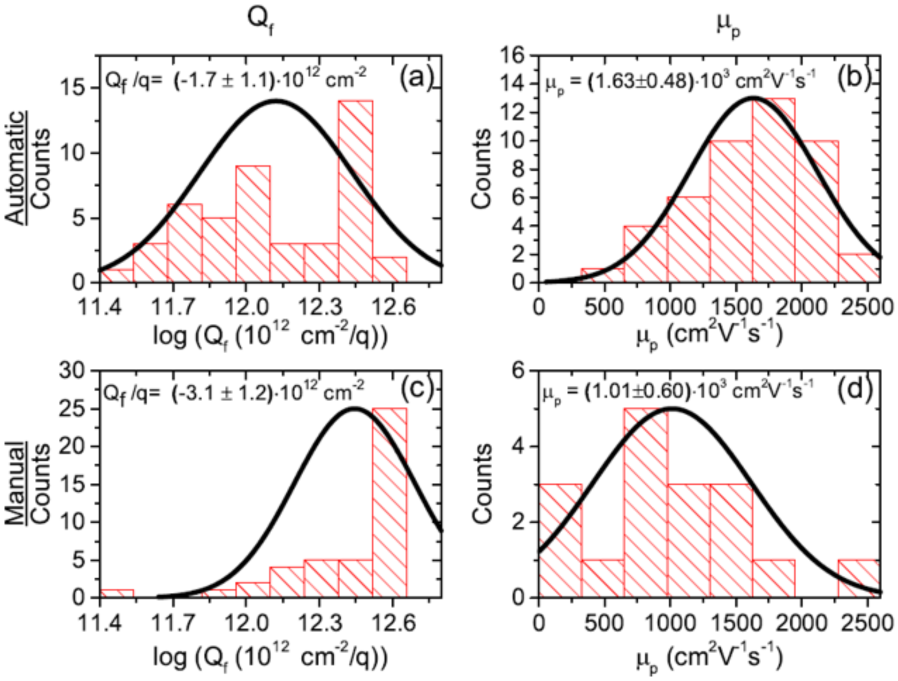

Figure 3: CVD graphene electrical characterization