Lab-scale system for automated graphene transfer

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Abstract

Although chemical vapor deposition (CVD) has proven to be an excellent method for growing electronic-quality graphene, its main disadvantage is the need of transferring the graphene layer from the metal catalyst to a suitable final substrate. A manual transfer method [1] 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 [2,3], 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 [4] can overcome some limitations of the manual method, but it is limited to flexible substrates.

In this work we report on 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 (Fig. 1) 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 demonstrate that devices on the automatically-transferred graphene present systematically higher mobilities and less impurity contamination.

References

[1]   Alfonso Reina, Xiaoting Jia, et al., Nano Lett., vol. **9**, **1** (2009), p. 30.
[2]   Wei-Hsiang Lin, Ting-Hui Chen, et al., ACS Nano, vol. **8**, **2** (2014), p. 1784.
[3]   Hai Li, Jumiati Wu, et al., ACS Nano, vol. **8**, **7** (2014), p. 6563.
[4]   Sukang Bae, Hyeongkeun Ri Kim, et al., Nat. Nanotechnol., vol. **5**, **August** (2010), p. 1.
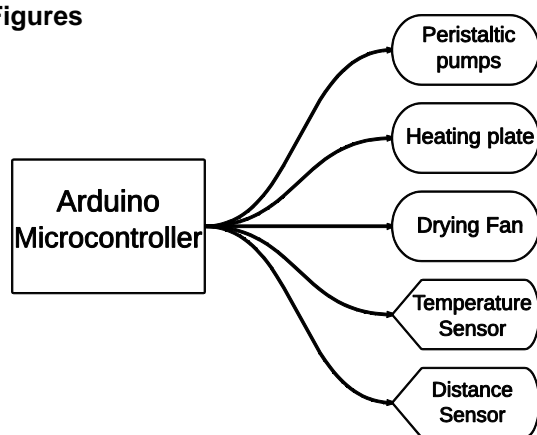
Figures

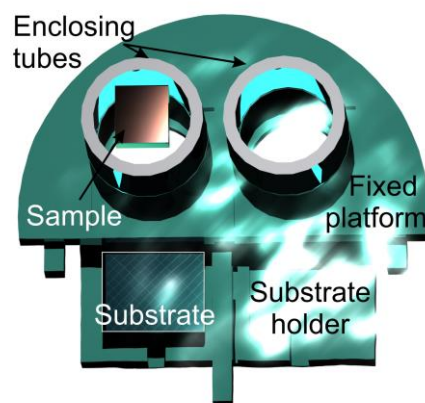Figure 1: System modules. An Arduino UNO board is used for interconnection and control

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