Monolayer Graphene Deposition on Copper and Silicon dioxide using NanoCVD-8G System

Md Azmot Ullah Khan, Naheem Olakunle Adesina, Jian Xu
Electrical and Computer Engineering, Louisiana State University, Baton Rouge, LA 70803
jianxu1@lsu.edu

In this paper, we present graphene deposition technique on copper (Cu) and silicon dioxide (SiO_2) using nanoCVD-8G system; The structure was characterized by Raman spectroscopy. Deposition of graphene on dielectric is essential for electronic application but involves indirect transfer from the metal catalyst at the cost of mechanical strain, wrinkles, and cracks in the transferred samples.[1, 2] Here, using the chemical vapor deposition method we report a direct deposition of graphene on the dielectric substrate to ensure easy and defect-free fabrication.

The system uses three types of gas precursors (Argon, H_2, and CH_4) that are delivered, controlled, and measured by gas delivery, valve, and gauge system respectively as shown in Figure. 1(a). Throughout the process, the temperature of the chamber was maintained at 100^0 C and the flow rate of H_2 and Argon at 20 sccm and 200 sccm. The overall process involves four steps as shown in Figure 1(b), 1. Elevation to growth temperature, 2. Annealing of the substrate, 3. Nucleation of graphene, 4. System cooling. We used .025 mm Alfa Aesar copper foil (99.999%) which was annealed before deposition for 10 mins at 1000^0 C to increase its grain size. Then, the temperature was increased to 1100^0 C and CH_4 was allowed to enter the chamber at a 20 sccm rate for nucleation. After 10 mins, the system was allowed to cool down to room temperature. The same procedure was followed for the SiO_2 substrate except the sample was cleaned for 30 sec separately using isopropyl alcohol, acetone, and DI water followed by baking at 220^0 C for 10 min.

Raman spectroscopy of graphene typically shows three major peaks, namely D, G, and 2D peaks. D peak indicates atomic defects and crystal disorder whereas G and 2D spectral lines denote crystal quality of the deposited sample and the number of deposited layers. In our case, the laser excitation energy for the spectroscopy was 30 mW at 633 nm wavelength. Our results in Figure. 1(c) and Figure. 1(d) show small D peaks at 1350 cm^{-1}, G peaks at 1580 cm^{-1}, and large 2D peaks at 2700 cm^{-1}. The stronger 2D peak in comparison to the G peak in both the samples signifies monolayer graphene deposition.

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[1] M. Her, R. Beams, and L. Novotny, Phys. Lett. A 377, 1455 (2013)

[2] W. -H. Lin, T. -H. Chen, J. -K. Chang J.-I. Taur, Y.-Y. Lo, W.- L. Lee, C.-S. Chang, W.-B. Su, and C.-I. Wu, ACS nano 8, 1784 (2014)

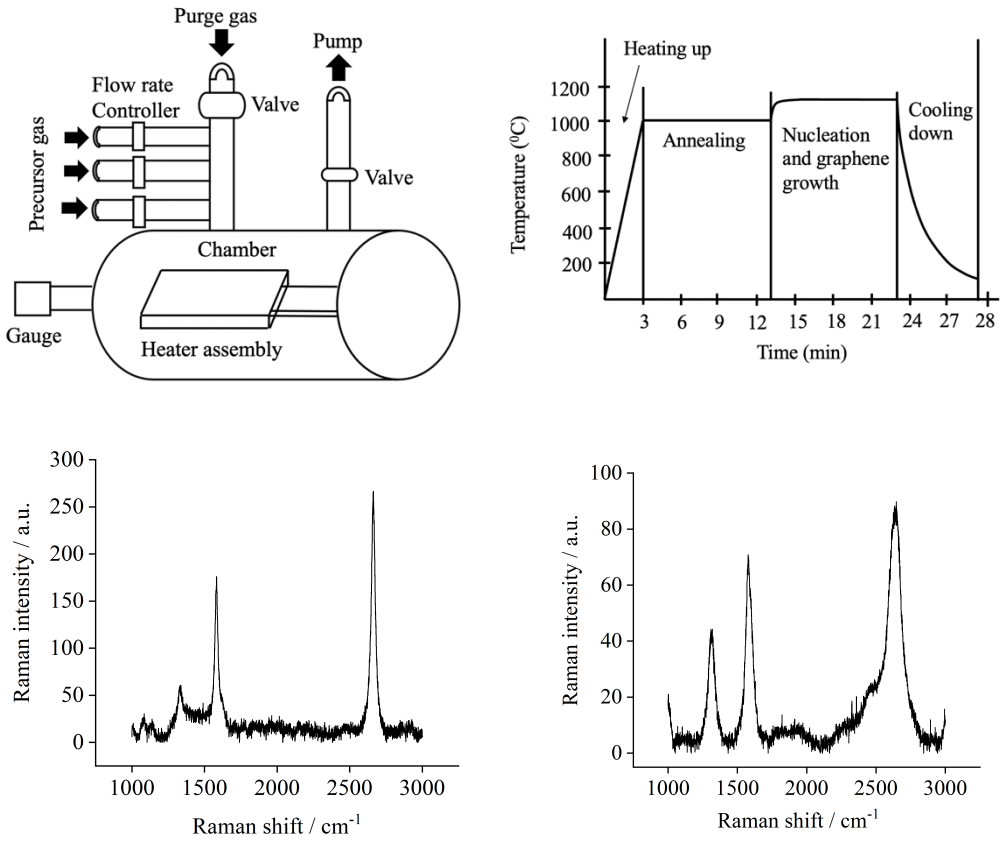

Figure 1(a): Schematic diagram of nanoCVD-8G graphene reactor. The arrow indicates the direction of gas flow. *Figure 1(b):* Different stages of graphene deposition process with time. *Figure 1(c):* Raman spectroscopy of graphene on copper substrate. *Figure 1(d):* Raman spectroscopy of graphene on SiO_2.