Fabrication of Graphene on Copper Using Photo-Thermal Chemical Vapour Deposition

J. Riikonen[1*], W. Kim[1], C. Li[1], O. Svensk[1], S. Arpiainen[2], and H. Lipsanen[1]

[1] Aalto University, Department of Micro- and Nanosciences, Micronova,
P.O. Box 13500, FI-00076 Espoo, Finland
[2] VTT Technical Research Centre of Finland, Microsystems and Nanoelectronics,
P.O. Box 1000, FI 02044 VTT, Espoo, Finland
* Corresponding author, email : juha.riikonen@aalto.fi

Fabrication of single-layer graphene films on copper foils by photo-thermal chemical vapor deposition (PTCVD) is demonstrated. The PTCVD furnace was realized installing additional gas controls in a rapid thermal processing (RTP) system typically used in wafer scale CMOS processing. The cold-wall RTP utilizes halogen lamps as a heat source. One significant benefit of using cold-wall RTP chamber compared to conventional hot-wall tube furnaces is the minimization of contaminating particles originating from the side walls. Photo-thermal heat source enables also faster heating and cooling rates compared to resistive heating due to minimized thermal mass. In industrial point of view, PTCVD can provide cost-efficiency due to batching capability and minimized process cycle times. Additionally, the process is straightforward to upscale as the temperature can be controlled over large areas in real-time. The PTCVD process using methane precursor in low pressure (10 mbar) shows very high growth rate as depending on the synthesis parameters uniform single-layer graphene films can be grown on copper only in 15 to 60 s. The pre-annealing step of copper foil carrier out in the PTCVD chamber at the growth temperature was 5 min. In addition to the obvious advantage of increased throughput, the capability of performing rapid process at high temperatures is also an effective way to reduce the deleterious copper evaporation. The effect of various synthesis parameters was studied by characterizing the crystalline quality, thickness and electronic properties of the films. The quality of the graphene films is equivalent to a typical CVD graphene. For example, as pointed out in Figure 1 the disorder induced D peak is not visible in the Raman spectra (E_{laser} = 2.33 eV) in graphene films fabricated at 950 °C (and transferred to a 300-nm-thick SiO_2/Si substrate). Moreover, the confocal µ-Raman mapping reveals high intensity ratio for 2D to G bands (mode I_{2D}/I_G ~ 3.4 for scanned area of 25 µm × 25 µm). All in all, our study shows that PTCVD can be used for the fabrication of high-quality single-layer graphene on copper with high throughput and is therefore a promising method for cost-effective graphene fabrication.

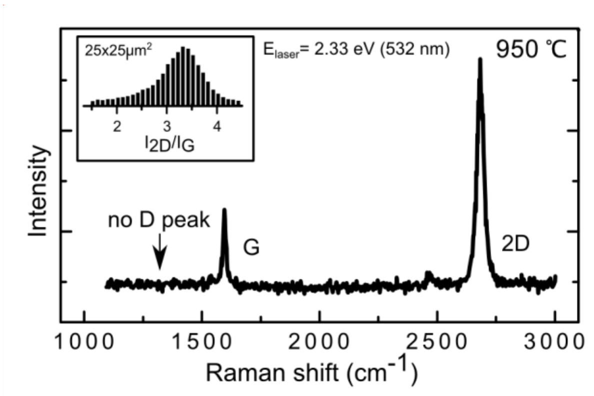

Figure 1. Raman spectrum of a graphene film fabricated at 950 °C (transferred onto a 300 nm SiO_2/Si). Inset shows histogram distribution of 2D to G band ratio determined from an area of 25 × 25 µm^2.