Direct growth of 2D and 3D graphene nano-structures over large glass substrates by tuning a sacrificial Cu-template layer

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Abstract
We demonstrate direct growth of two-dimensional (2D) and three-dimensional (3D) graphene structures on glass substrates. By starting from a catalytic copper nanoparticle soot of proper geometry and using chemical vapour deposition (CVD) techniques, different morphologies can be obtained, including graphene sponge-like (3D-GS), nano-ball (3D-GB) and conformal graphene structures (2D-G). Importantly, we show that the initial copper template can be completely removed via sublimation occurring during CVD and, if need be, subsequent metal etching. In this way optical transmissions close to the initial bare substrates are achieved, which, combined with electrical conductivity make the proposed technique very attractive for creating graphene with high surface to volume ratio for a wide variety of applications, including antiglare display screens, solar cells, light-emitting diodes, gas and biological plasmonic sensors.

References

[1] X. Cao, Z. Yin, H. Zhang, Energy Environ. Sci. 7 (2014) 1850.
[2] Z. Chen, W. Ren, L. Gao, B. Liu, S. Pei, H.-M. Cheng, Nat. Mater. 10 (2011) 424–428.
[3] S. Lee, J. Hong, J.H. Koo, H. Lee, S. Lee, T. Choi, H. Jung, B. Koo, J. Park, H. Kim, Y.W. Kim, T. Lee, ACS Appl. Mater. Interfaces. 5 (2013) 2432–2437.
[4] S. Mao, K. Yu, J. Chang, D. a Steeber, L.E. Ocola, J. Chen, Sci. Rep. 3 (2013) 1696.

Figures

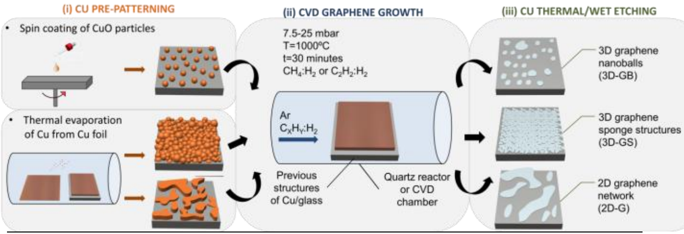

Figure 1: Fabrication of 3D and 2D-graphene structures. (i) Cu template formation on the substrate by CuO particles spin-coating or by thermal evaporation from a Cu foil. Pictures on the right side show the final Cu geometries on the substrate: isolated, multi-layer or large Cu NPs embedded in glass. (ii) CVD growth of graphene on the Cu template. (iii) Removal of residual Cu by wet etching or sublimation.

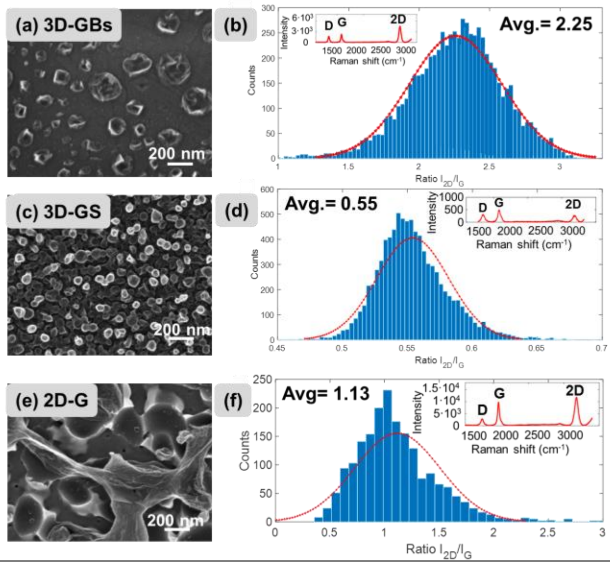

Figure 2: (a,c,e) SEM images show the morphology of each 3D-GB, 3D-GS and 2D-G structure while (b,d,f) show the corresponding Raman measurements, respectively. The graph shows a Gaussian distribution of the ratio between I_{2D} and I_G peaks (I_{2D}/I_G) over an area of 20x20 μm^2. Top corners show the mean values of I_{2D}/I_G. Insets: Raman spectra of each structure showing typical graphene peaks: D, G and 2D.