Towards transfer-free fabrication of graphene NEMS

Niclas Lindvall, Jie Sun, Galib Abdul, and August Yurgens

Department of Microtechnology and Nanoscience, Chalmers University of Technology, SE-41296 Gothenburg, Sweden
niclas.lindvall@chalmers.se

Many exciting applications of graphene are based on combining several of the extraordinary properties of this material. Graphene shows great potential in nanoelectromechanical systems (NEMS) where its large mechanical strength, flexibility and electrical conductivity make it a unique material. Adding a very low mass and true two-dimensional nature, it may find its applications in several new types of sensor devices.

Recently, there has been large progress in the large-scale synthesis of graphene grown by chemical vapor deposition (CVD) [1-5]. This material exhibits excellent mechanical- and electronic properties and suspended graphene resonators have been demonstrated and characterized. However, the fabrication involves the transfer of graphene from its copper catalyst to the target substrate by a wet chemical etching method. This transfer procedure introduces metal residues, wrinkles and holes in the graphene. Due to these issues, there is a need for a transfer-free fabrication method for suspended graphene structures grown by CVD.

We fabricate suspended graphene without the need for graphene transfer. Graphene can be grown either catalytically on thin copper films, or non-catalytically directly on a dielectric substrate. A typical fabrication procedure includes the growth of graphene by CVD followed by the deposition of Au/Ti electrodes defined by e-beam lithography (ebl) and graphene etching using oxygen plasma. The structures are made suspended by chemical etching of the top substrate layer (copper or silicon dioxide) and are critically point dried.

We perform electrical-, mechanical- and optical characterization as well as scanning- and transmission electron microscopy to verify the graphene properties. Scanning electron micrographs of typical devices are shown in Figure 1. While its electronic properties are inferior to those of graphene grown on high quality copper foils, it shows remarkable mechanical strength. The sheet resistivity is typically in the order of 100 kΩ, making it, so far, unsuitable for high-frequency devices. However, with further improvement of the material quality, this work constitutes steps forward towards transfer-free fabrication of graphene NEMS grown by CVD.

References

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Figures

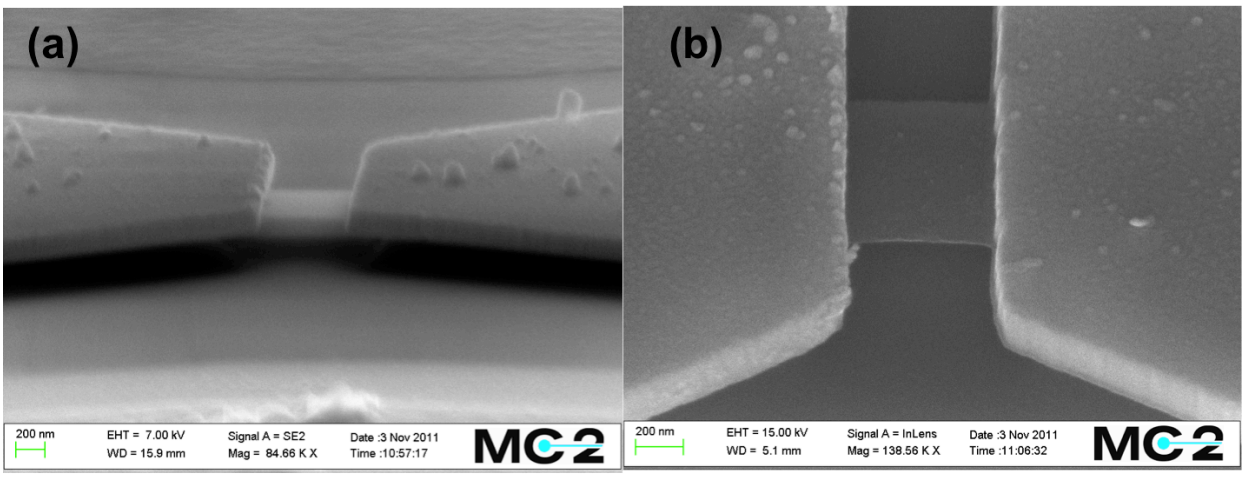

Figure 1. (a) Side view and (b) top view scanning electron micrographs of suspended graphene membranes fabricated with a transfer-free chemical vapor deposition method. The graphene is suspended over a silicon dioxide substrate between two gold electrodes.