# Morphological characterization of metallic nano-structures evaporated through stencil on graphene

V. Savu[1,2], C. Nef[1], V. Flauraud[2], W. Fu[1], J. Brugger[2], C. Schönenberger[1]
[1]*University of Basel, Institute of Physics, Klingelbergstrasse 82, CH-4056 Basel, Switzerland*
veronica.savu@epfl.ch

[2]*Ecole Polytechnique Fédérale de Lausanne, Microsystems Laboratory LMIS1, Batiment BM, Station 17, CH-1015 Lausanne, Switzerland*

It has recently been shown that metals can tune the doping type of graphene as a function of different metal configurations.[1] It has also been proven that the uncontrolled doping from organic impurities like PMMA can be eliminated when a stencil is used to deposit electrical contacts on graphene.[2] In this work we characterize the morphology of metal nanostructures deposited through a stencil on graphene and compare the metal diffusion on graphene and other insulating substrates. As a tool for the characterization of the graphene quality, we use micro-Raman spectroscopy of large-area suspended graphene.

The CVD graphene grown on Cu foil was covered with 300 nm PMMA, the Cu was etched in ammonium persulfate and the graphene/PMMA rinsed in water. [3] The graphene was transferred onto 500 nm thick low-stress SiN membranes. For assessing the quality of the transferred graphene, micro-Raman spectroscopy (532 nm laser) was performed on the graphene membranes suspended across apertures up to 100 μm long in the SiN, as seen in Fig. 1a-c.[4] The intensities of the G-band at 1576 $cm^{-1}$ and of the 2D-band at 2680 $cm^{-1}$ maintain a high ratio across the membranes, as seen in Fig. 1d-f. 60 nm Ag was evaporated through nano-apertures in 100 nm thick SiN stencil membranes on both graphene and SiN.[5] The morphology of the Ag nanostructures depends on the substrate and on the pattern geometry. On graphene, the faster diffusion of the metal atoms results in larger coalesced islands around the main nanostructures, as seen in Fig. 2.

The temperature dependence of this behavior as a function of material and structure geometry is explored as an option for smart engineering of metal deposition on graphene. One of the envisioned applications is metallic electrodes with nano gaps fabricated by using resistless stencil lithography on graphene.

---

[1] Y. P. Wu, et al., Small **8**, 3129 (2012)

[2] W. Z. Bao, G. Liu, Z. Zhao, H. Zhang, D. Yan, A. Deshpande, B. J. LeRoy, and C. N. Lau, Nano Res. **3**, 98 (2010)

[3] W. Y. Fu, C. Nef, O. Knopfrnacher, A. Tarasov, M. Weiss, M. Calame, and C. Schonenberger, Nano Lett. **11**, 3597 (2011)

[4] R. A. Barton, B. Ilic, A. M. van der Zande, W. S. Whitney, P. L. McEuen, J. M. Parpia, and H. G. Craighead, Nano Lett. **11**, 1232 (2011)

[5] O. Vazquez-Mena, T. Sannomiya, M. Tosun, L. G. Villanueva, V. Savu, J. Voros, and J. Brugger, ACS Nano **6**, 5474 (2012)

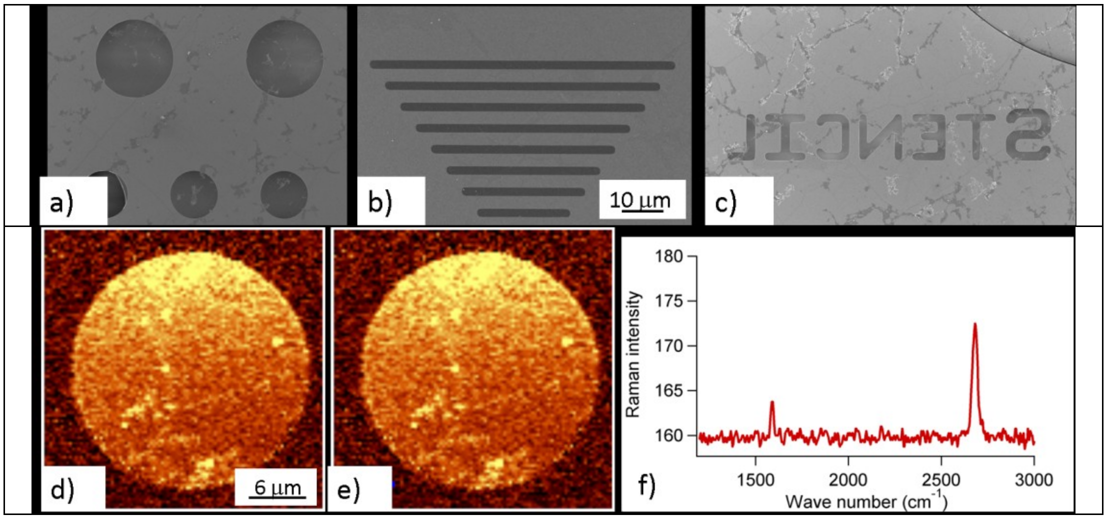


*Figure 1: SEM micrographs of graphene membranes suspended on 500 nm thick low-stress SiN:* a) arrays of membranes with diameters up to 26 μm, b) rectangular membranes up to 100 μm long, and c) the word "STENCIL" in reverse. *Micro-Raman data for 26 μm diameter suspended graphene membrane:* maps of the integrated intensity of the d) G-band, e) 2D-band, and f) representative intensity spectrum showing high-quality single layer graphene.

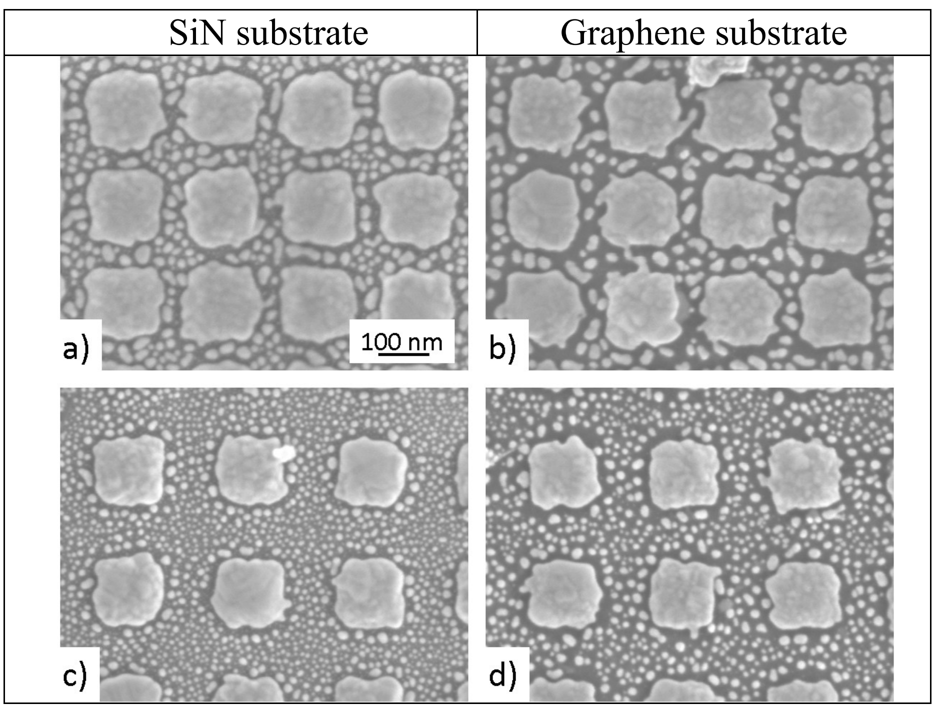


*Figure 2: SEM micrographs of 60 nm Ag evaporated through nano-stencils on the same die:* a) 150 nm side squares, 50 nm apart, on SiN and b) on graphene, c) 130 nm side squares, 120 nm apart on SiN and d) on graphene. The higher density of Ag nanoclusters around the main structures on SiN is due to the lower mobility of the material on graphene than on SiN.