Technological integration of CVD grown graphene membranes for thermal and thermoelectric applications

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Graphene is a fascinating new material [1], and its peculiar properties hold promises for a great technological impact [2]. Nevertheless, to allow for a real exploiting of their extraordinary properties, a complete control of the different steps leading to the fabrication of graphene-based devices is mandatory. In this contribution we will show how an integrated approach, from the synthesis methodologies, through the complete structural and functional characterization, up to the integration in technological processes, is capable to open interesting perspectives for the exploitation of graphene properties in particular in thermal and thermoelectric sensing applications.

Among extraordinary graphene properties, thermal transport has received increasing attention only recently. The atomic layer thickness, the lightweight and the high crystalline order of the lattice lead to a very high thermal conductivity near room temperature making graphene an extraordinary candidate for thermal management applications in electronic devices [3-5]. Nevertheless, despite the theoretical prediction, only few experimental measurements of thermal and thermoelectric properties can be found in the literature, because the complete control of the structural properties of deposited graphene layers as well as the proper tailoring of device characteristics is still an issue.

An integrated approach to the study of graphene thermal and thermoelectric properties, with the aim of including graphene films directly in the technological design process of testing devices, will be presented (see Fig. 1). The proposed approach starts from the characterization of the thermal and thermoelectric properties of Chemical Vapor Deposition (CVD) grown graphene membranes (see Fig. 2) as a function of their structural characteristics (degree of crystallinity, grains density, defects, numbers and dimensions of the layers, as measured by Transmission Electron Microscopy (TEM) techniques), then moving to the integration of the graphene films directly in the technological design process of testing devices, to determine the requested technological steps to achieve a full integrability of the membranes within the processes for the fabrication of micromachined sensing device such as bolometers and thermopiles.

References

[1] K. Novoselov et al., Science, **306** (2004), 666.
[2] A.K. Geim et al., Nat. Mater., **6** (2007), 183.
[3] A.A. Balandin et al. Nano Lett. **8** (2008), 902.
[4] S. Chen et al. ACS Nano **5** (2011), 321.
[5] Z. Wang et al. Nano Lett. **11** (2011), 113.

Figures

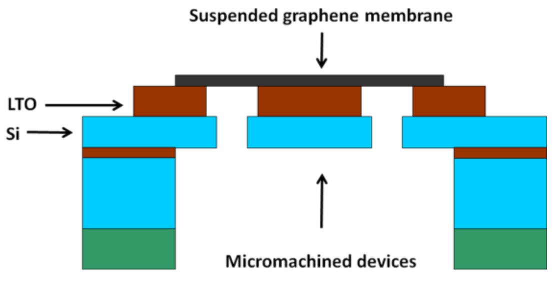

Figure 1: Schematics of the micromachined device to test the thermoelectric properties and integrating the graphene membrane directly in the process

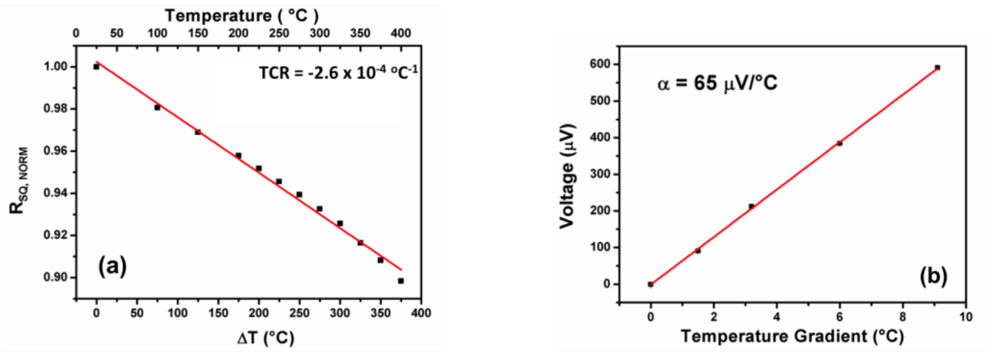

Figure 2: (a) Thermal Coefficient of Resistance (TCR) and (b) Seebeck coefficient (α) of CVD grown graphene membranes.