Towards transfer-free large area fabrication of gas filtration devices based on a suspended porous graphene mono-layer.

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Mono-layer graphene, which is both atomically thin and impermeable to Hydrogen (H2) and Helium (He), appears as an ideal membrane material for the filtration of such small molecules. Ultimate performances of permeation and selectivity were predicted, since the generation of sub-nanometer pores in graphene with a sufficiently high density and a narrow size distribution could be controlled [1]. However, experimental realizations of such filtration devices based on a suspended porous mono-layer [2, 3] or bi-layer [4] graphene membrane remain scarce with performances below their expected potential. Two main technological challenges has to be faced. The first one consists in the fabrication of a basic building block based on an intact graphene mono-layer suspended on a holed substrate with a high opening area. In the suspension areas, the graphene layer should be free of holes, cracks or tears with dimensions higher than one nanometer to be H_2 or He-tight. Then, the second challenge consists in engineering sub-nanometer pores in this intact graphene layer, without affecting the material integrity elsewhere.
For the first time, in order to target a future industrial fabrication, this work aimed at addressing all these challenges while providing an innovative process flow suitable for batch fabrication of several devices in parallel at the wafer scale, using conventional technologies of the semi-conductor industry on silicon. Chemical vapour deposition was chosen as a scalable method to elaborate the graphene mono-layer and its integration was achieved without transfer step, known to be responsible for graphene damaging on large areas. Graphene was grown directly on a pre-patterned holed SOI (Silicon On Insulator) substrate and successfully released without damages above most of micro-sized holes (figure 1). Promising results were also obtained for the controlled generation of sub-nanometer pores in graphene thanks to nitrogen doping via plasma technologies.

References

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Figures

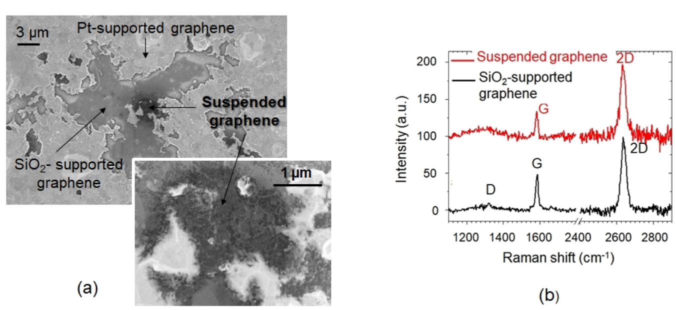

Figure 1: Intact graphene mono-layer suspended above a 3 µm-diameter hole. (a) SEM and (b) associated typical Raman spectra at 633 nm.