**Fabrication of solid-state nano-pore graphene composite membranes**

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Introduction

Nano-pore membranes are currently being investigated for several promising applications such as ultrafiltration, dialysis, ion pumps and biosensors (Dekker 2007, Lee 2018). For these purposes, mechanical and chemical robustness is required. On the other hand, theoretical approaches suggest that single-layered nano-porous graphene has excellent potential for a variety of applications, including molecular sieving, DNA sequencing and energy science [Heerema 2016, Garaj 2010]. However, the graphene layers are fragile and require support. In the present study, we report on the fabrication and characterization of graphene composite nano-pore membranes.

Methods

The free-standing membranes are fabricated by deposition of SiO2 on Si wafers using plasma-enhanced chemical vapour deposition (PECVD) and selective removal of the substrate in an area of size 0.55 mm x 0.55 mm using standard Micro-Electro-Mechanical Systems processing. Subsequently, large-area single-layer CVD graphene is transferred to the membranes. The membranes are then irradiated with 185 MeV and 1.6 GeV Au ions at the 14UD Pelletron Accelerator at the Australian National University and the UNILAC Linear Accelerator at GSI Helmholzzentrum für Schwerionenforschung, respectively. This leads to the formation of ion tracks in SiO2 which are subsequently etched for different times hydrofluoric acid in a custom-built etching cell to form nano-pores. The composite membranes are characterized using synchrotron-based small angle X-ray scattering (SAXS), Scanning Electron Microscope and Atomic Force Microscopy while the defects generated by the irradiation are investigated using Raman spectroscopy. SAXS is a non-destructive powerful technique to determine ion track and nano-pore morphologies with high precision [Hadley 2019].

Results

The etching leads to the formation of conical and double conical shaped microchannels in the PECVD layers. The defects in graphene formed during the ion irradiation are aligned with the underlying SiO2 pores, and results indicate that the graphene top layer remains unaffected by the etching. The conical-shaped pores can increase the rate of transport drastically, relative to regular cylindrical pores, thus increasing the applicability of the nano-porous composite graphene membranes for fast and selective separation processes.

Conclusions

We present a comprehensive characterization of the nano-pore membranes, the influence of the graphene layer on the pore formation process and the defects generated in the graphene by the ion irradiation process.

References

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