Fabrication of nanofluidic devices based on isolated single walled carbon nanotube for coupling ionic and electronic transport

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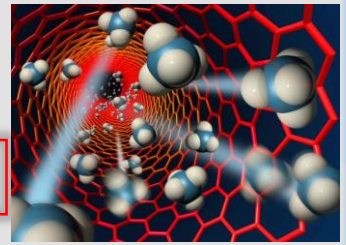
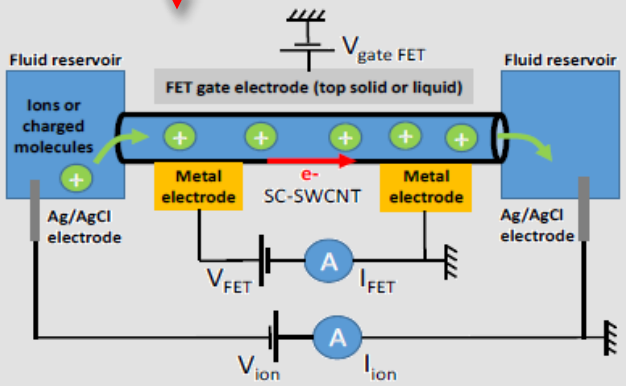
Introduction

Single-Walled Carbon Nanotubes (SWCNTs)



- Molecule confinement
- Selectivity
- Low friction
- Coupling electronic and ion transport

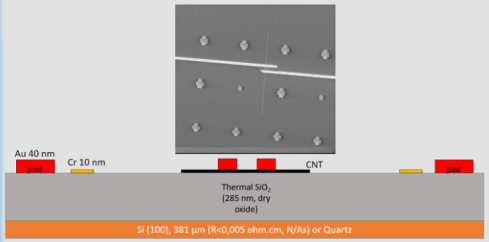
Objectives



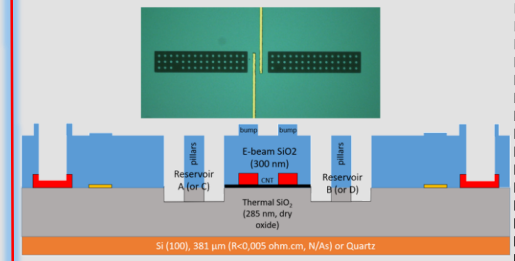
Study the influence of :

1) SWCNT edge functions on ionic transport
2) Electronic surface charges on ion transport through metallic-SWCNTs
3) Inner ion species in real time on the electronic transport of a semiconducting – SWCNT – Field Effect Transistors (FET)

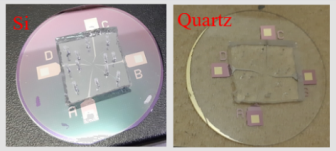
Device fabrication

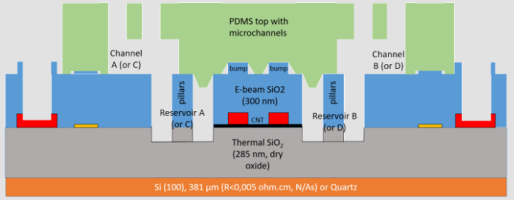


1) Fabrication of optical marks
2) Transfer of CNT on the substrate (silicon or quartz)
3) Deposition of electrodes (Cr/Au/Cr) on the selected CNT by lithography followed by lift-off

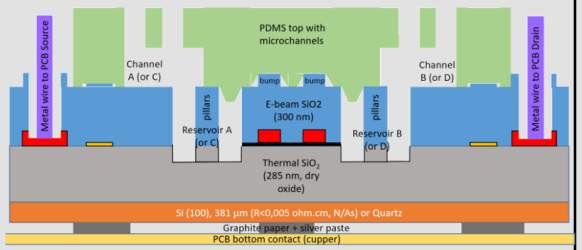


4) Cover with SiO_2 layer by electron beam evaporation
5) Etch reservoirs and pad accesses and open the NTC by reactive ion etching





6) Sealing the device by PDMS owing microfluidic channels. NB : for quartz substrate, a top gate electrode should be fabricated before PMDS sealing



7) Create electrical connections
8) Fill and measure ionic transport

Ionic measurements (primary results)

Silicon substrate :

Photosensitive, electric leaks, high noise and periodic spikes, conductance = 100 pS at 1V for [KCl] = 0,1 M without CNT

Quartz substrate :

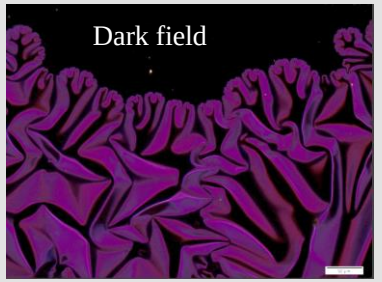
No electric leaks, low noise and no spikes, conductance = 1 pS at 1V for [KCl] = 0,1 M without CNT (to be considered as the baseline current)

Optimizations for device fabrication

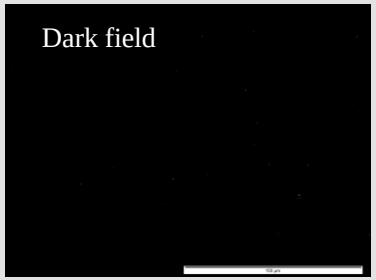
1) Process of SWCNTs transfer on substrates **(CAB instead of PMMA)**

2) Cleaning process to eliminate totally the photoresist in lift-off for better surface quality (**acetone + remover PG at 80 °C)**

3) Adhesion improvement of the SiO_2 layer **(annealing after deposition at 200 °C for 1h)**



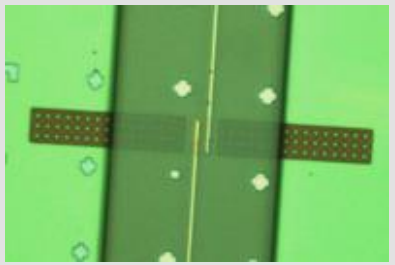
Without annealing



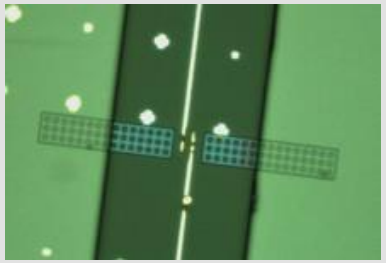
With annealing

4) Parameters calibration for reservoir etching and NTC opening

5) Required pressure to seal PDMS without plugging reservoirs



PDMS plugs the reservoirs



PDMS does not plug

Conclusion

- All steps of fabrication of the nanofluidic device are validated on silicon and quartz substrates
- Quartz are more suitable than silicon substrates for ionic measurements
- Such platform on quartz including CNT will be the next step for investigating coupling between ionic and electronic transport.