Project updated: 02.12.2019

Tunneling nanogap electrodes fabrication by capillary-assisted particle assembly

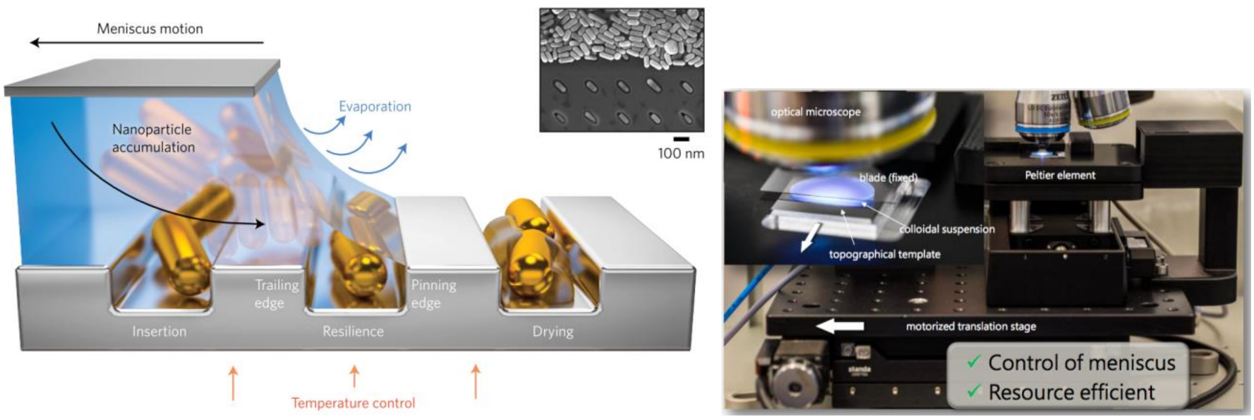
Semester/Master Project

(Section: microengineering)

Nanogap electrodes (NGEs) comprise a pair of electrically conducting materials separated by a nm-scale air gap. Over past decades, NGEs have been utilized in applications such as molecular detection, nanoantennas, and next generation DNA sequencing. For nanogaps in the < 4 nm regime (so-called tunneling NGEs), the exponential dependence of the tunneling current on the gap width makes NGEs interesting for cases where the tunneling NGEs is mechanically tunable on a stretchable substrate.

In this project, the goal is to fabricate tunneling nanogap electrodes using the technique called “capillary-assisted particle assembly (CAPA)”: as shown in the image below, when the moving meniscus passes over predefined traps, the capillary force inserts Au nanorods into traps while dragging away excessive nanorods on the hydrophobic silanized substrate surface.

Starting with the trap design and the e-beam lithography to fabricate nanoscale traps on the substrate in the CMi, and then conduct sequential CAPA process to assembly nanogap electrodes and study the yield performance with the scanning electron microscope (SEM). Finally, if applicable, another e-beam lithography process to fabricate the metal lead for the tunneling current measurement.



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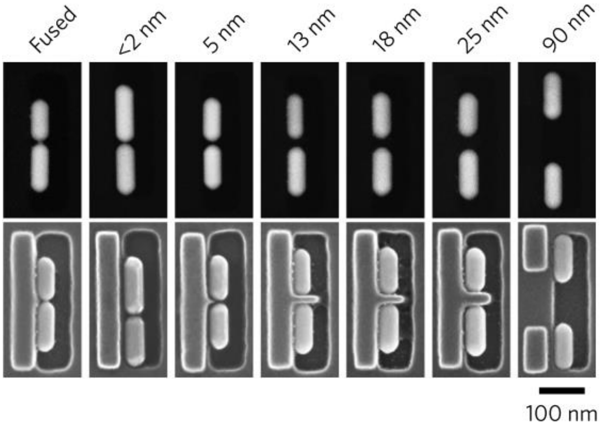
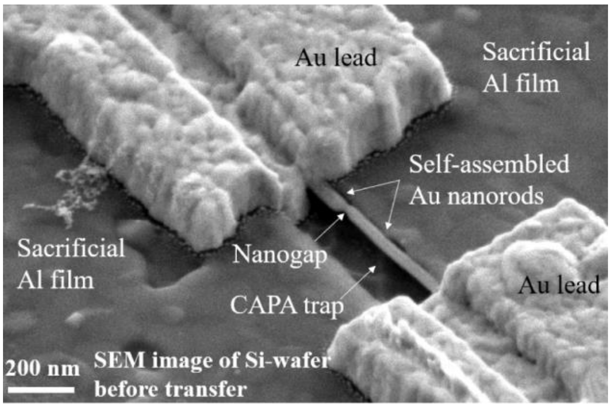
Project updated: 16.09.2019





Work description:

- Trap design and GDS preparation
- E-beam lithography in CMi: RIE and lift-off
- CAPA process strategy development and yield study
- Tunneling nanogap electrodes electrical characterization (if applicable)

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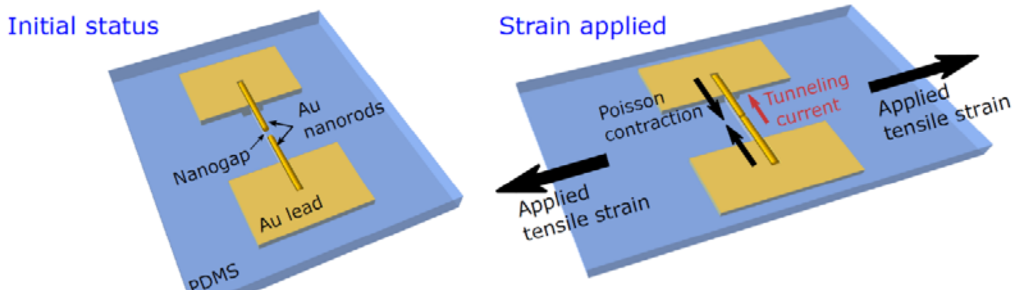
Multi-physics finite element analysis (FEA) simulation for mechanically tunable tunneling nanogap electrodes

Semester Project

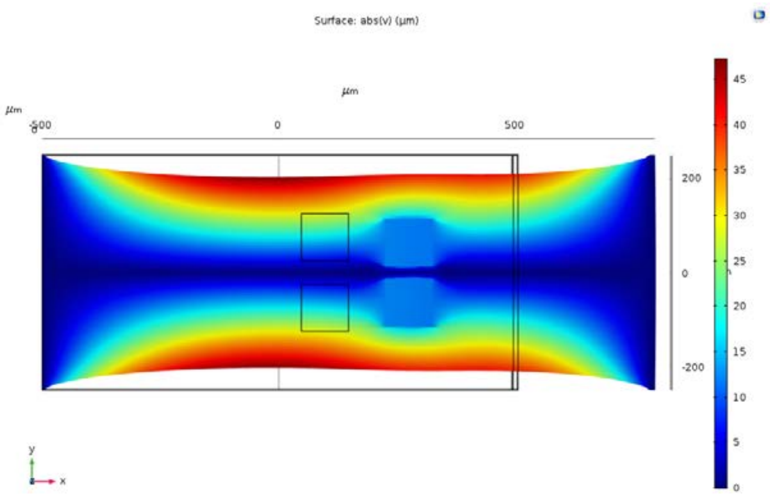
(Section: microengineering)

Nanogap electrodes (NGEs) comprise a pair of electrically conducting materials separated by a nm-scale air gap. Over past decades, NGEs have been utilized in applications such as molecular electronics, nanoantennas, and DNA sequencing. For nanogaps in the <3 nm regime (so-called tunneling NGEs), the exponential dependence of the tunneling current on the gap width makes NGEs interesting for cases where the tunneling NGEs is mechanically tunable on a stretchable substrate.

In this project, the goal is to establish a COMSOL multi-physics FEA simulation model for mechanically tunable tunneling nanogap electrodes. This model will integrate the solid mechanics and the tunneling current estimation as a reference to the experimental result.



Working principle of tunable NGEs on PDMS



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Work description:

- COMSOL model establishment for NGEs on PDMS
- Parametric simulation study
- Visualization of simulation results including animations

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Project updated: 02.12.2019

Immobilization of hybrid-single-walled carbon nanotubes for nanoelectronics

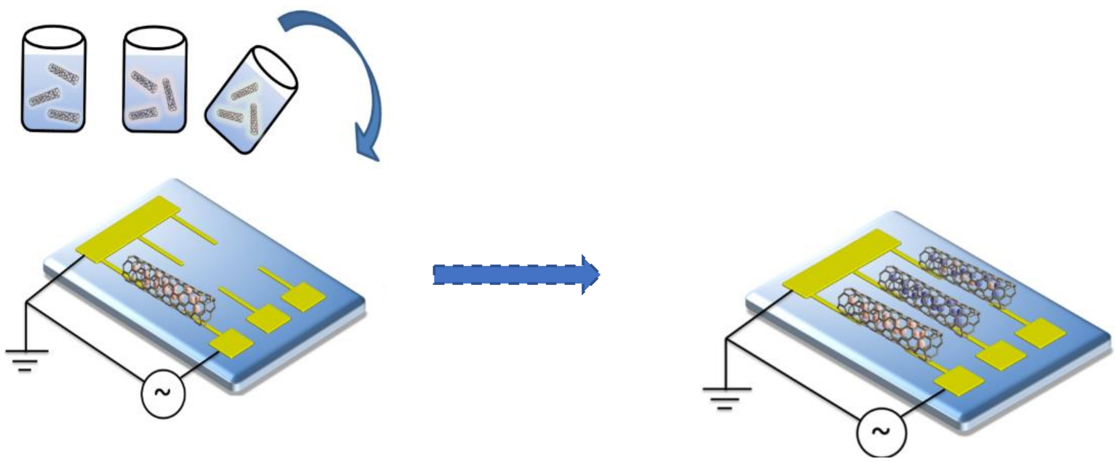
Semester Project / Master Project / Internship

(Section: microengineering, material science)

The ability to control the arrangement of materials into highly oriented structures with nanoscale accuracy is of great importance, for a variety of applications including nanoelectronics, energy storage and nanomedicine. In particular, there has been great interest in the use of one-dimensional nanostructured materials such as single-walled carbon nanotubes (SWCNTs). A solution processable approach enables their linear deposition between specific electrode pairs in electronic devices.

This project is divided in 2 subprojects:

Subproject 1: Immobilization of SWCNTs by dielectrophoresis



A way to immobilized SWCNTs from solution to the device is to use the dielectrophoresis. It is then possible to trap different kind of SWCNTs on the same chip. Parameters such as applied voltage, time of deposition and concentration of SWCNTs solution need to be optimized in order to immobilize only a bundle (few tens) of SWCNTs. A full electrical characterization will be performed on the device created and Atomic force microscopy will be used to identify the SWCNTs immobilized.

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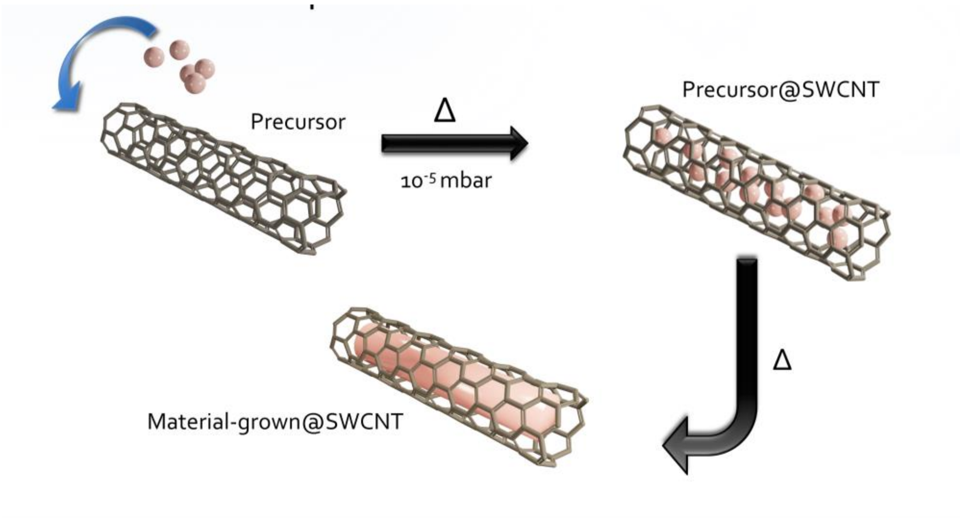
Subproject 2: Growing of nanowires using SWCNTs as a nanoreactor template



SWNTs, due to the confinement effects enabled by their nanoscopic tubular design, have been employed as 1D templates to control the position and orientation of molecules or atoms for the construction of nanoscale 1D architectures. The aim here is to first fill SWCNTs with organometallic precursors and then perform a thermal annealing to grow the material inside the tube. The samples will be characterized by high-resolution transmission electron microscopy and possibly integrated on a chip (with the method afforementionned).

Work description:

- SWCNTs assembly by dielectrophoresis
- Identification by atomic force microscopy
- Electrical characterization of SWCNT in FET configuration
- Glass sealing under vacuum (filling of SWCNTs)
- High-resolution transmission electron microscopy

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