Master Thesis - Structural and thermoelectric characterization of polycrystalline silicon nanotubes

Description:

Large amounts of waste heat generated in our fossil-fuel based economy can be converted into useful electric power by using thermoelectric generators. However, the low-efficiency, scarcity, high-cost and poor production scalability of conventional thermoelectric material hinder their mass deployment. Nanoengineering has proven to be an excellent approach for enhancing thermoelectric properties of abundant and cheap materials such as silicon. Nevertheless, the implementation of these nanostructures is still a major challenge especially for covering the large areas required for massive waste heat recovery.

Recently, a family of nano-enabled materials in the form of large-area paper-like fabrics made of nanotubes has been developed as a cost-effective and scalable solution for thermoelectric generation. These fabrics composed of p-type silicon nanotubes show a five-fold improvement of the thermoelectric figure of merit. Outstanding power densities above 100 W/m^2 at 700°C were demonstrated opening a market for waste heat recovery [1].

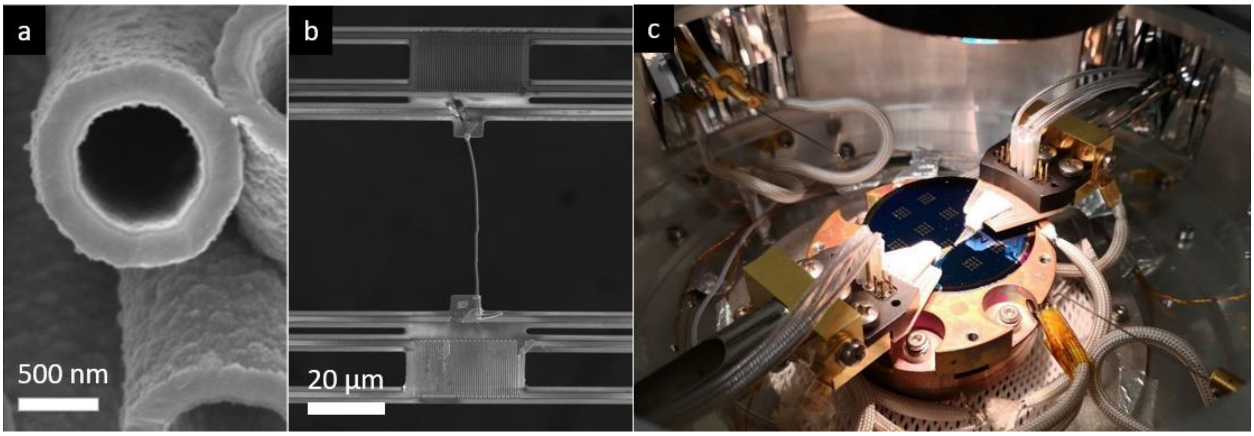

Figure 1. a) Scanning Electron image of one polycrystalline silicon nanotube. The inner shell is composed of silicon oxide. b) Suspended membranes with electrical heaters hosting a single nanotube for its thermoelectric characterization. Temperature controlled probe station used for the measurements. A laser can also be focused on the sample to perform Raman spectroscopy.

However, the thermoelectric properties of single nanotubes are still unknown. Understanding their dependence with their crystallinity and morphological features such as inner and outer diameter, grain size and residual stress is of great interest to further enhance their thermoelectric conversion efficiency.

In this project, electrothermal measurements using microdevices featuring suspended membranes will be carried out in order to asses the thermoelectrical properties of the described nanotubes. Different microscopy techniques (such as optical, scanning electron microscopy and transmission electron microscopy) will be used to morphologically characterize the nanotubes. Additionally, Raman spectroscopy can be carried out to complete the study of the crystallinity and thermal properties of the nanotubes.

Laboratory:

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References:

[1] Morata. et al. "Large-Area and Adaptable Electrospun Silicon-Based Thermoelectric Nanomaterials with High Energy Conversion Coefficients". Nature Communications, 2018.