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Suspended crystalline silicon thermometry devices : towards quantum nanophononics

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This work addresses the current experimental gap in thermal transport regimes and phonon transport at low temperatures and small scales. These conditions cause the wavelength λ and mean free pass l of phonons to become equal or greater than the sample's dimensions, giving rise to several interesting quantum phenomena, hence the name quantum nanophononics. Multiple phenomena are expected to be studied: Phonon interferometric effects [1], thermal rectification, quantization of thermal transport [2], etc...

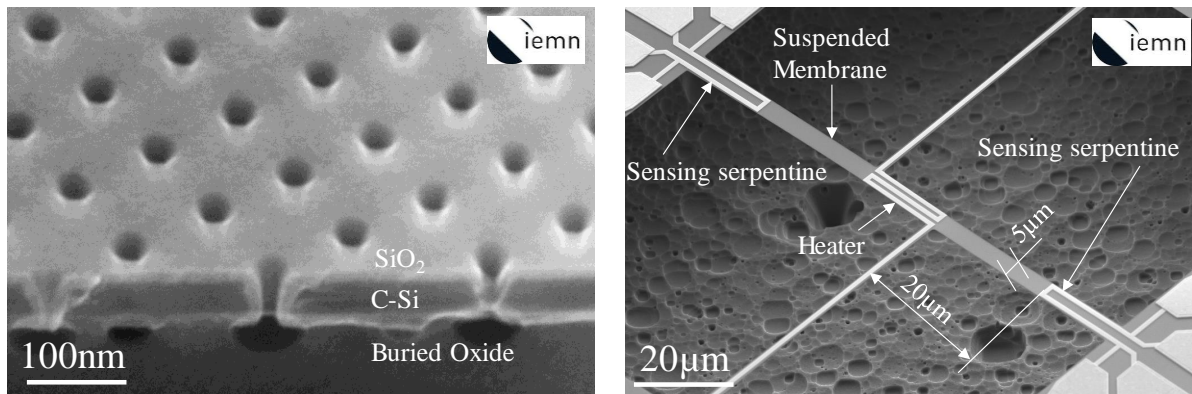


Figure 1: Left: SEM picture of a c-Si layer with nanopores. Right: Device-scale view of the c-Si suspended membranes.

In previous work [3] (Figure 1), a silicon membrane suspension process was successfully used to obtain thermal characterization platforms. Here, the challenge is to adapt this process towards the fabrication of a different design of suspended systems [4], produced from silicon-on-insulator (SOI) wafers by means of micro-/nano-fabrication techniques, mainly based on e-beam lithography and reactive ion etching (RIE). The top-down process allows for different kinds of samples to be placed in between the sensing platform (NWs, patterned membranes, etc...). Sensing is performed by two superconducting NbN thermometers located on each thermal reservoir. The goal is to improve the system to reach a sensitivity of zeptowatts (10^{-21} W). With this poster, we want to share the scientific and technological challenges associated to those measurements. Especially, we will show our latest results in terms of sample fabrication and characterization.

- [1] N. Zen, T. Puurtinen, T. Isotalo et al., Nature Communications **5**, 3435 (2014).
- [2] K. Schwab, E. Henriksen, J. Worlock et al., Nature **404**, 974 (2000).
- [3] M. Haras et al., IEEE Electron Device Lett. **37**, 1358 (2016).
- [4] A. Tavakoli, Nature Communications **9**, 4287 (2018).