Minicolloque n° OPS27 ■ **Oral** ☐ **Poster**

Mesoporous materials for opto-phononic sensing devices operating in the gigahertz range

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Coherent manipulation of acoustic waves at the nanoscale usually requires multilayers with thicknesses and interface roughness defined down to the atomic monolayer. [1] This results in expensive devices with predetermined functionality. Due to the high surface-to-volume ratio and tailorable mesopores of mesoporous materials, the incorporation of chemical functionalization to nanoacoustics is possible. Here, we present multilayered resonators based on mesoporous silicon dioxide (SiO_2) and titanium dioxide (TiO_2) with acoustic resonances in the 5-100 GHz range. [2] The devices consist of a mesoporous layer followed by dense oxide and an optoacoustic nickel transducer on top. We characterize the acoustic response using coherent phonon generation and detection experiments. [3] Figs.1(a) and (b) show experimental results and simulations of phononic modes in structures with and without the mesoporous layer, respectively. Modes up to 30 GHz are confined within the mesoporous layer. Simulations show remarkable agreement with experiments.

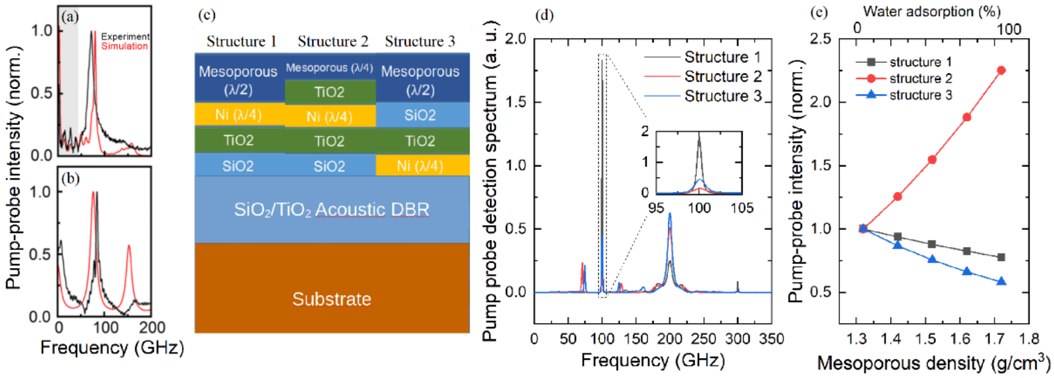

Figure 1: Experimental results (black) and simulations (red) of the phononic modes on SiO_2 structures (a) with (b) without mesoporous layer; (c) Layer configuration of the proposed SiO_2 mesoporous surface acoustic cavity structures; (d) Simulations of the pump-probe spectra for the proposed structures; (e) Simulation of the pump-probe intensity at 100 GHz as a function of mesoporous density.

In sensing applications, the mesoporous layer has to have access to the environment and thus be the outermost layer in a structure. [4] We designed new structures based on surface mesoporous spacer cavity on top of an acoustic distributed Bragg reflector to confine phonons at 100 GHz (Fig. 1(c)). Simulations show strong coherent-phonon signals at the designed frequency and potentially high Q-factors (Fig. 1(d)). Water adsorption by the mesopores increases the structure density, which induces a substantial variation in the phononic signal (Fig 1(e)), a required feature for sensing applications. Our findings unlock the way to a promising platform for nanoacoustic sensing and reconfigurable optoacoustic nanodevices based on soft, inexpensive fabrication methods.

[1] F.R. Lamberti, et al, Appl. Phys. Lett. 111, 173107 (2017)

[2] N. L. Abdala, et al, J. Phys. Chem. C 124, 17165 (2020)

[3] C. Thomsen, et al, Phys. Rev. B 34, 4129 (1986)

[4] G. Benetti, et al, ACS Appl. Mater. Interfaces 10, 27947 (2018)