Fabrication of free standing single copper nanowires for vibrational response study through transient reflectivity

L. Belliard, L. Becerra, N. Kacemi, B. Perrin
Sorbonne Universités, UPMC Univ. Paris 06, CNRS, UMR 7588, Institut des NanoSciences de Paris, 4 Place Jussieu, Boîte 840, F-75005, Paris, France
becerra@insp.jussieu.fr

T.W. Cornelius, O. Thomas
Aix-Marseille Université, CNRS, IM2NP, UMR 7334, Faculté des Sciences, Campus de St Jérôme, Avenue Escadrille Normandie Niemen - Case 142, F-13397 Marseille cedex, France

M.E. Toimil-Molares, M. Cassinelli
GSI Helmholtz Centre for Heavy Ion Research, Planckstr, 1, D-64291 Darmstadt, Germany

We report on the elaboration of free standing copper nanowires on structured silicon substrate. Taking advantage of the mechanical coupling suppression between the nanostructures and the substrate, we have obtained nano oscillators exhibiting high quality factors. Thanks to the investigation by femtosecond transient reflectivity measurements and the use of 2D finite element simulations, we observed a very good agreement between experimental and simulated frequencies. We demonstrated elastic confinement in free standing wires which allowed the detection of up to the third harmonic of the breathing mode. By removing the energy relaxation channel towards the substrate, we fabricated nano oscillators with quality factors up to 130.

Copper nanowires, with diameters ranging from 100 nm up to 500 nm, were prepared by electrodeposition in etched ion-track membranes.[1] To fabricate the membranes, 30 µm thick polycarbonate foils were irradiated with ~GeV Au^{25+} ions. After irradiation, the so created latent tracks were selectively etched in a NaOH solution, resulting in cylindrical smooth nano channels. We then sputtered a thin layer of Au on one side of the membrane. The layer was reinforced electrochemically with Cu, and served as cathode in a two-electrode electrochemical cell, while a Cu rod served as anode. After nanowires growth, the polymer membrane was dissolved in dichloromethane, and the wires were detached from the cathode by ultrasonification. In a final step, the nanowires were drop-casted onto a structured Si substrate (Figure 1). Indeed, in order to reduce the influence of the Si substrate on the dynamic response, we dispersed the wires on a Si(001) wafer which has been preliminary structured with periodic trenches. Dry oxidation, photolithography, BHF etching and anisotropic KOH etching, lead to the formation of the desired trenches network. These 2 µm depth trenches are aligned along the <110> direction, with a periodicity close to 10 µm.

[1] M.E. Toimil-Molares, V. Buschmann, D. Dobrev, R. Neumann, R. Cholz, I. U. Schuchert, and J. Vetter, Adv. Mater. 13, 62 (2001).

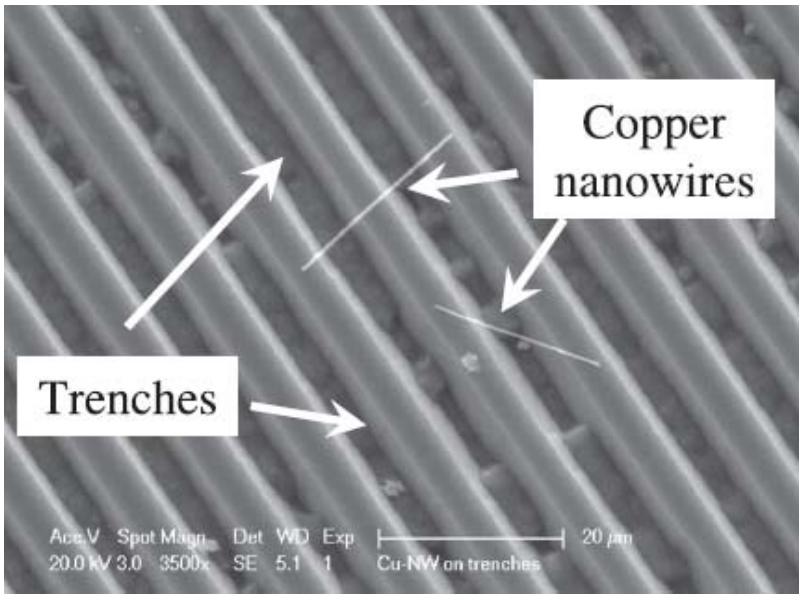

Figure 1: SEM image showing two single copper nanowires placed across pyramidal trenches fabricated by lithography and anisotropic silicon etching.