NANO HIGHLIGHT
Functionalized Nanowires for Electromechanical Detection of Molecules

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Nano-electromechanical systems (NEMS) are emerging as processes are being developed for fabricating structures in the nanometer dimensional range. While offering vastly expanded capabilities such as unprecedented sensitivity to force or to added mass, NEMS present engineers with unprecedented challenges in materials processing, device design, fabrication and integration.

Two approaches are utilized for accessing the nanometer domain, the top-down (derived from standard microfabrication paradigm of thin-film deposition, lithography and etching) and bottom-top (synthetic approach). By merging the top-down and bottom-top approaches, we have been able to achieve *lateral* growth of silicon nanowires with controlled size and density. In one approach, galvanic displacement is combined with microemulsion techniques to *selectively* deposit catalyst nanoparticles on Si, followed by vapor-liquid-solid growth of Si nanowires [**1**]. In the second approach, size-selected gold clusters are deposited followed by the VLS growth [**2**]. Combining these with microfabricated trenches exposing two opposite vertical Si(111) sidewalls, we have obtained singly and doubly clamped beam-like suspended nanostructures, with controlled diameter, density and lengths (Fig. 1). These are important steps towards the realization of a number of NEMS-based devices, including mechanical resonant sensors, nanoseparation devices and thermoelectric generation.

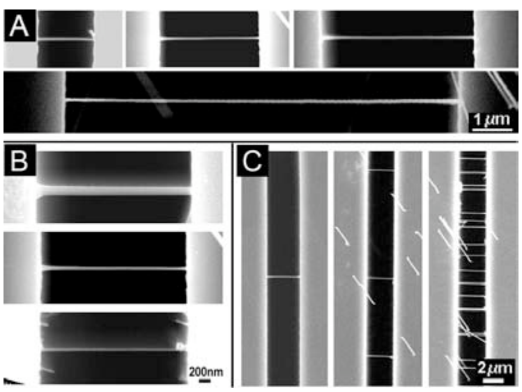

Fig. 1. Control of length (A), diameter (B), and density (C) of bridging Si nanowires. A) The lengths of the four nanowires with similar diameters of ~ 75 nm are 1.5, 2.5, 4 and 10 μm respectively. B) The diameters of the three nanowires are 140, 70, and 35 nm from up to down. C) The densities are 1 wire/50 μm, 4 wires/50 μm, and 40 wires/50 μm from left to right.

Atomic force microscopy is employed to characterize the mechanical elasticity of these suspended Si nanowires [**3**]. Our experiments provide direct evidence of the mechanical rigidity of the clamping ends of these self-assembled nanowire-in-trench structures. We have also demonstrated the beam-like mechanical behavior of these nanostructures by measuring linear elastic deflections of the nanowires under normal forces applied by the microscope tip and then comparing the results with the theoretical behavior of singly and doubly clamped elastic beams.

References

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[2] R. He, D. Gao, R. Fan, A. Hochbaum, C. Carraro, R. Maboudian and P. Yang, "Si Nanowire Bridges in Micro-trenches: Integration of Growth into Device Fabrication", *Advanced Materials* **17**, 2098 (2005).
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