Nanopelleting of Carbon Nanotubes - SNS

Personnel

T. El-Aguizy, Y. Jeon, J.-H. Jeong , S.-G. Kim

Sponsorship

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Concepts and Design

A novel method of decoupling the growth and the assembly of carbon nanotubes (CNT) is invented. The objective of this project is to make a long range ordered CNTs on a large area, which has not been possible with the existing nanotube growing processes. Nanopelleting is the technology to transform carbon nanotubes into the handlable and manufacturable form with which the existing micro-scale manufacturing processes can be utilized, such as fluidic self assembly or MEMS manupulators. To achieve this, small blocks (nanopellets) of material encapsulating CNTs with known length and alignment are going to be made. The CVD growth of individual free-standing nanotubes in arrays of Silicon trenches followed by the encapsulation and CMP will form nanotube-embedded nanopellets. Various self-assembly methods can then be utilized to locate the individual nanopellets at points of use. The nanopelleting material must allow for selective release from the substrate material as well as selective removal of the nanopellet material without affecting the CNTs.

Fabrication Methods & Results

Fabrication of the silicon trenches can be achieved utilizing anisotropic wet etching of (100) wafers to allow for well-defined sloping sidewalls that facilitate self-assembly. The desired geometry and periodicity can be achieved by tailoring the mask pattern and etch parameters to achieve the desired geometry and periodicity in the resulting trenches. Nickel nanodots with diameters of several microns are currently used as the catalyst patches CNT growth. Interference lithography and x-ray lithography are well suited for patterning periodic patterns in the sub-micron regime, and we investigate their potential for patterning sub-micron (200nm) nanodots aligned with the etched trench patterns.

Several methods exist for growing single or multi-walled CNTs, including arc discharge and CVD methods. Plasma Enhanced (PE) CVD methods provide a reliable, low-cost option for growing well-ordered, aligned CNT over large areas. We have established collaboration with Z.F. Ren of Boston College to utilize their PE-CVD device for growth of aligned CNTs. Advantages of this approach include the lower temperatures required for nanotube formation, the flexibility in the range of catalytic materials used, and the inherent e-field that assists in growth of aligned CNTs.

We investigate various materials for filling the nanopellets to satisfy the functional requirements. Spin-coated M-Bond epoxy is found to allow selective release of the nanopellets from a silicon substrate utilizing xenon di-fluoride (XeF_2) as well as the selective removal of the M-Bond without attacking the CNT utilizing oxygen plasma etching. We also investigate the possibility for utilizing conventional chemical-mechanical planarization methods to eliminate any excess filler material, leaving independent nanopellets with well-defined geometry encapsulating aligned CNTs with well-defined lengths and diameters.

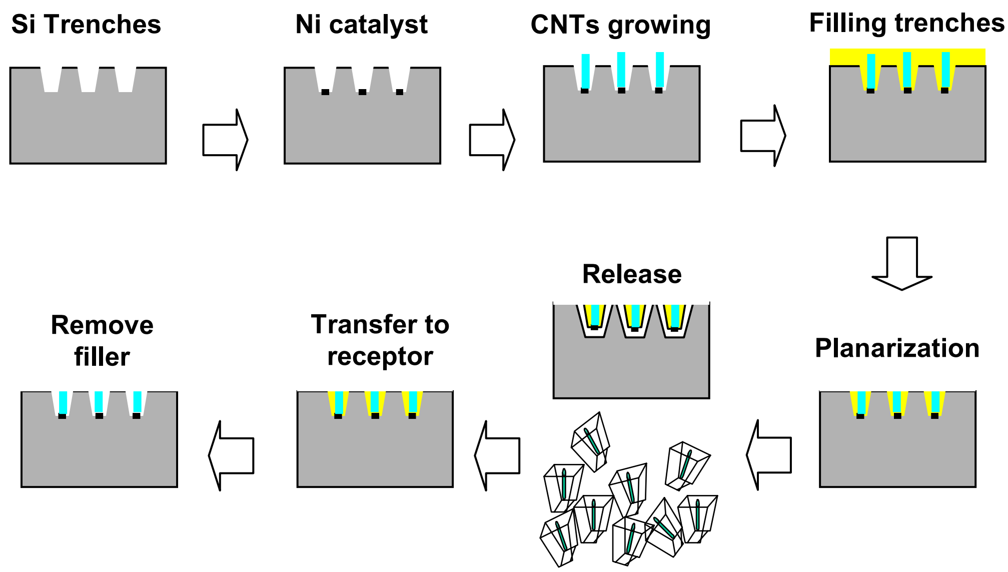

Fig 1. Nanopelleting of CNTs

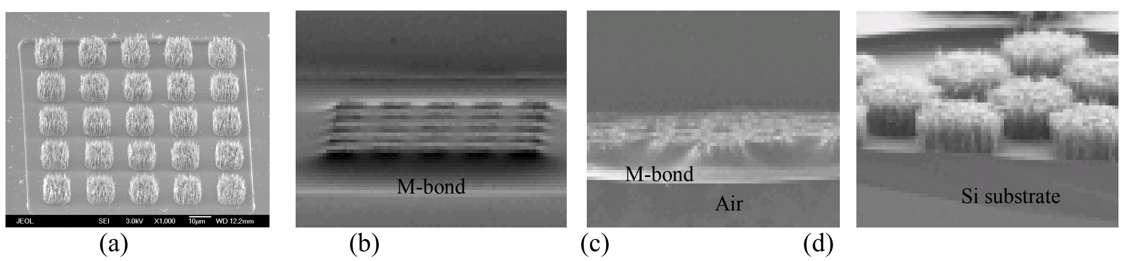

Fig. 2 SEM images of the CNTs (a) Grown CNTs, (b) Filled with M-bond, (c) Released M-bond pellet by XeF_2 (not planarized) and (d) CNTs after filler removal by O_2 plasma (not planarized)