

Arianne Filoramo (Gif-sur-Yvette CEA Caclay, ENS Paris and Motorola Labs) - Non-covalent binding of DNA to carbon nanotubes controlled by biological recognition complexes:

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Introduction: Integrated circuit scaling trends and roadmaps, Moore's Law and Density of silicon devices. Motivation: problem to scale down to sub 10-nm is costly. Seek alternatives to traditional electronics. 1959 Feynam: "There is plenty of room at the bottom", 2004 "which one is technology is most interesting." Alternative candidates to CMOS, issues for sub 10-nm scaling: sensitive to variation of their physical dimension, power/energy dissipation, speed, cost. What's needed to go beyond? Bottom-up construction using self-assembly, multi-disciplinary expertise, new system architecture. Molecular and nanoscale electronics: Using DNA strands as a scaffold and self-recognition, decide to work with carbon nanotubes (CNT). CNT have exceptional properties, well characterized mechanical, capillary, and electrical properties. Different types of devices make, junctions, gates, all fabricated by random depositions. Have to first find with AFM, how to make compatible with large-scale fabrications? Selective placement via surface preparation and manipulation. Selective attachment, lithography, resist protection/clean, stick patch formation with gaseous APTS deposition, lift-off resists, exposed to CNT solution, yield of deposition of 100% on APTS, 100 nm wide patterns. Next step is to connect CNT to allow fabrication of integrated devices. Put gates on nanotube after deposition. Still requires lithography. Can use DNA to contract. DNA-SWNT: covalent or non-covalent chemistry. Perfect nanotube is not possible to perform via covalent chemistry: COOH/COO^- defects are needed. Strong acid treatments are required to obtain this chemistry. Sonicate for several hours, possibly with ill effects such as lowering transport performances. E.g. Raman spectroscopy, SP_2 to SP_3 transitions appear to have been effected. Nanotubes are very sensitive to their environment. Examples of chemically modified characteristics: Transport and optical absorption can completely change for better or worse (mostly worse). Functionalization of CNT by DNA strands e.g. through streptavidin (SA) and biotin complex. SA has hydrophobic interactions with CNT, AFM shows decoration with SA bumps. Then Biotin-DNA will attach to tubes, attached to APTS treated mica. Unfortunately the DNA can attach anywhere. 10kB DNA was used in the AFM example shown here. When DNA is not biotinilated DNA does not bind. Even with strong mechanical action, like washing, anchorage persists. Depositions followed by combing of DNA on surface gives alignment. Double biotin DNA can bind to same carbon nanotube. Studied DNA conductivity and in our experiments it does not appear to be conductive. So we chose DNA metallization. Similar results to Mertig et al., unfortunately nanotube metallizes as well. RecA polymerization, challenge is to go beyond standard lithography using the DNA to localize the CNT.