Viacarbon

Carbon Nanotubes for Interconnects and Switches

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Partners

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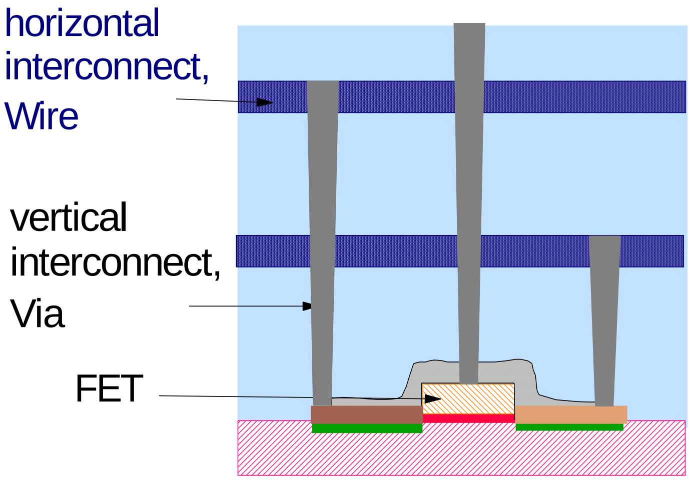
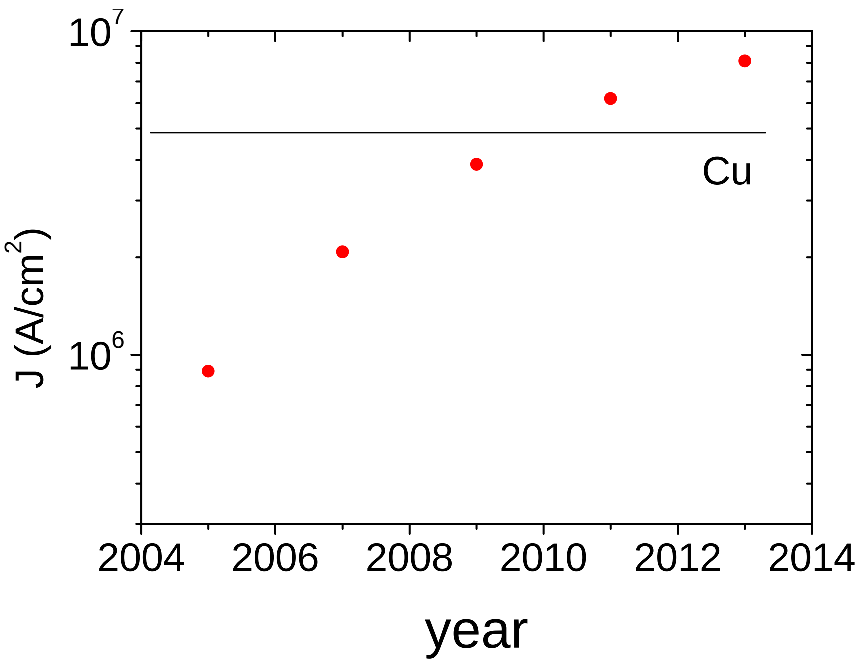
Background

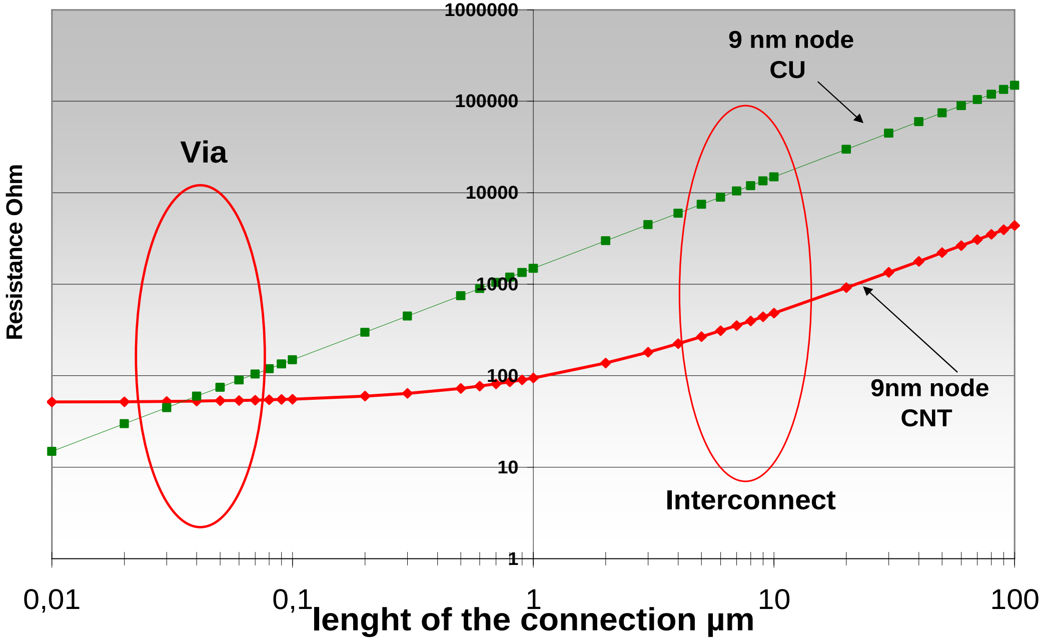
- ITRS roadmap needs interconnects with J > 5.10^6 A/cm^2 beyond 22 nm node
- beyond limit of Cu
- Carbon nanotubes are only material to carry J = 10^9 A/cm^2 without failure by electromigration
- 'There is no (electrical) alternative'
- *But, practical implementation of CNT interconnects is quite uncertain, no technology*

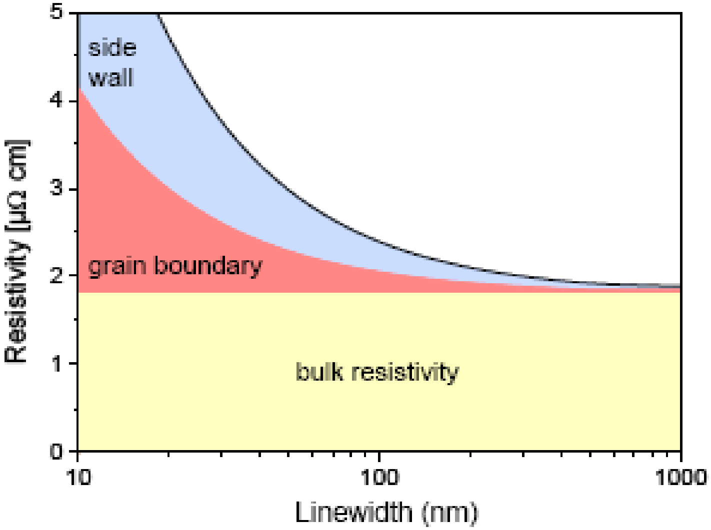




Requirement

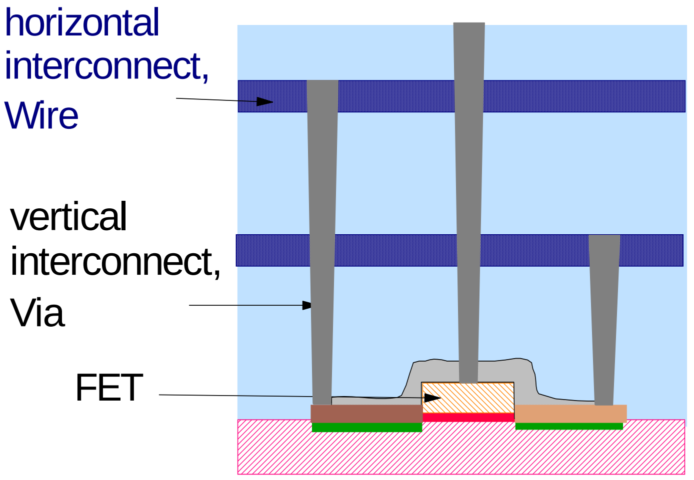
- CNTs = 1D conductors, limited by quantum of conductance, $G_0 = 4h/e^2$/channel $\rightarrow R = 6.5K\Omega$
- G_0 acts as series resistance
- Difficult to get R below Cu for vertical Vias, but easier for horizontal Wires
- Need very high density of CNT channels in parallel
- Need single-walled nanotubes
- densities over 10^{13} cm^{-2}
- 3 nm spacing





Objectives

- Develop an industry-compatible process for vertical interconnects
- Develop an industry-compatible process for horizontal interconnects
- Optimize growth catalyst and process conditions for SWNT density ~10^{13} cm^{-2}
- Low resistivity contacts, total R < 50 Ω
- Fabricate MNWT-based NEMS capacitive switch,
  - C_{on}/C_{off} >100 for 2-5 GHz

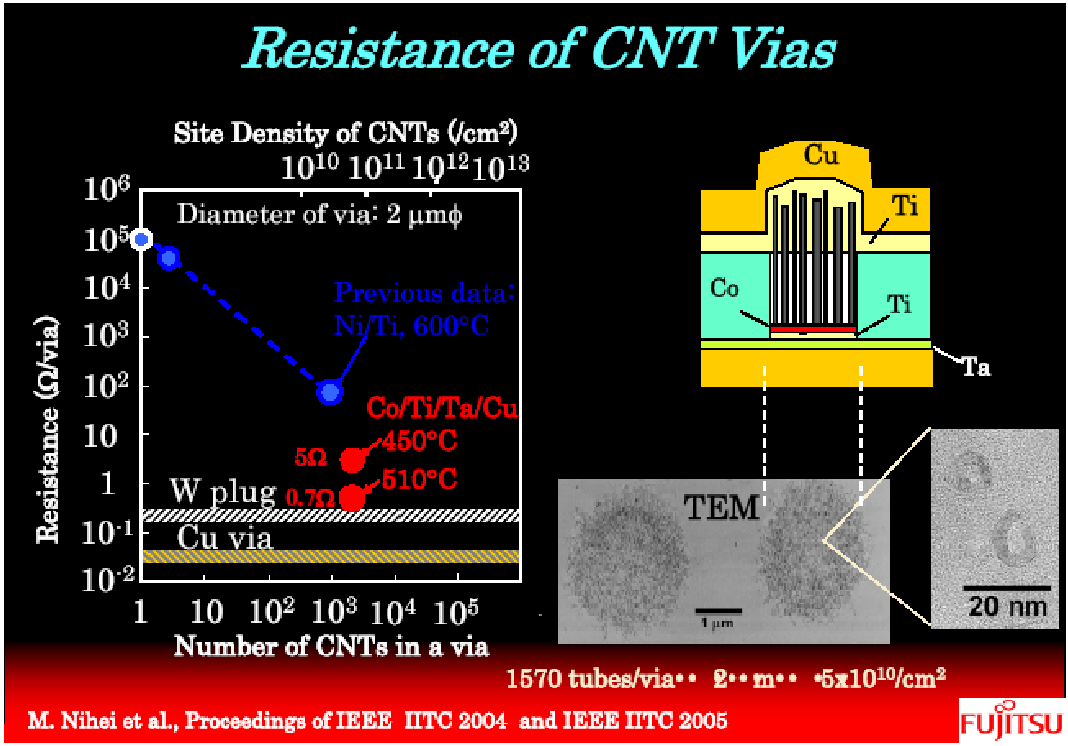


Previous work, Vias

- Leading work in Europe in 2003 was by Infineon

- Leading work presently Fujitsu
- They have reached $n=10^{11}$ cm^{-2}

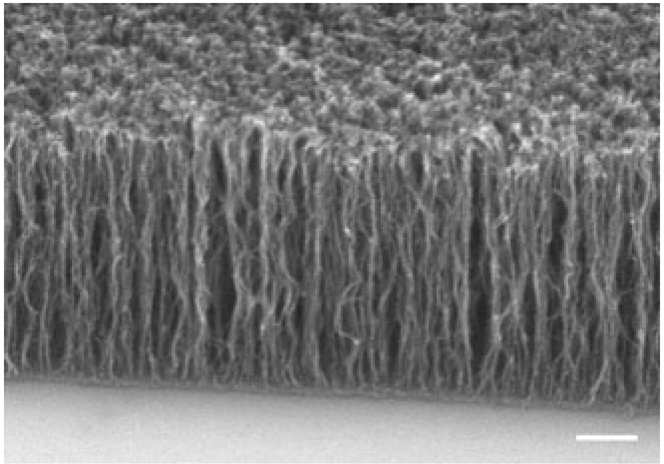
- In addition, many technical problems

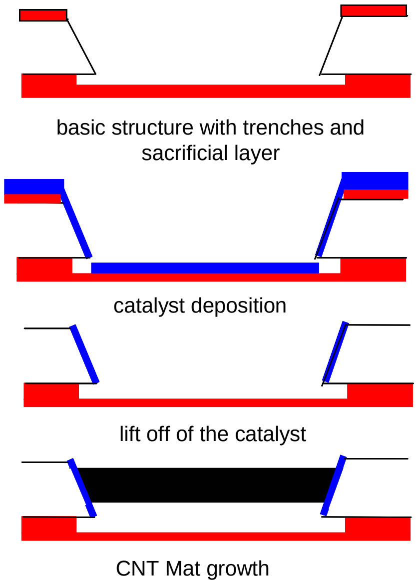


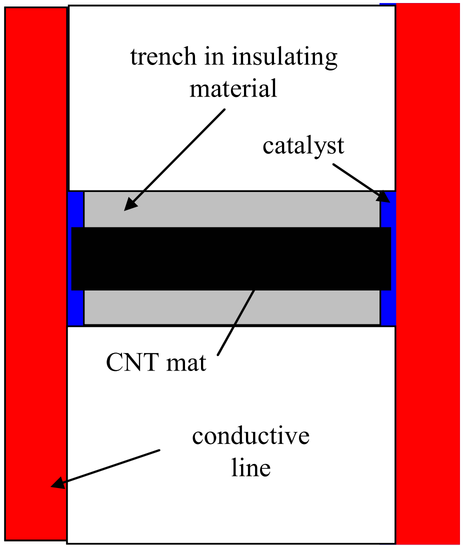
Technology

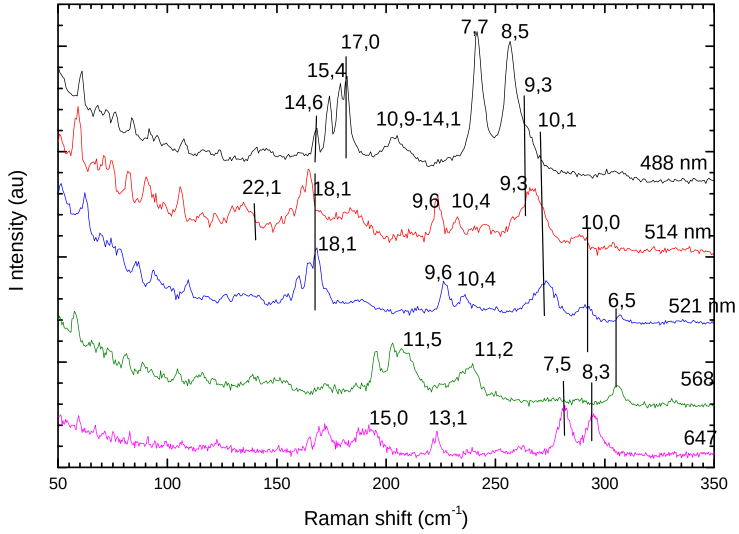
- High density nucleation for Vias – catalyst design
- Catalyst deposition (cluster dep)
- Characterisation (TEM, Raman)

- Top contacts
- Side-wall catalysts for Wires
- Coated trenches









NEMs

- Nanotubes have very high stiffness, low density, and large current carrying capacity
- In principle, good NEMs material

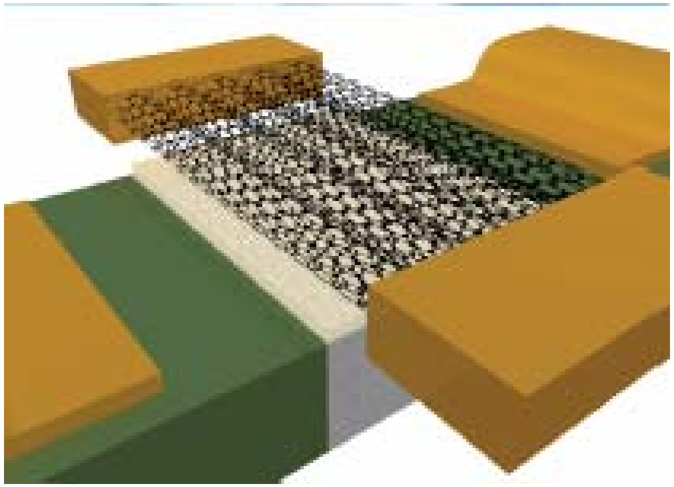
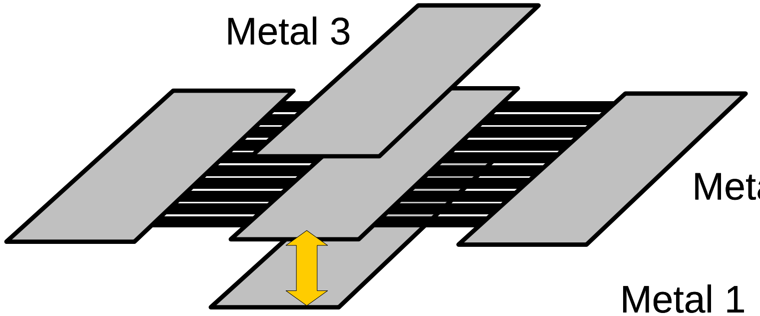


Fig. 3. Schematic of a NEMS relay.

- Horizontal RF NEMs switch

- Based of growth techniques developed for Wires



Expertise of partners

- Ucam - nanotube growth, catalyst design, characterisation
- CEA - nanotubes, processing, integration
- EPFL - NEMs, modelling, nanotubes
- Intel - processing, integration, end-user

Work packages

WP	title
1	Growth optimisation
2	Vertical interconnect technology
3	Horizontal interconnect technology
4	RF NEMs