Ultrahigh Conductive Materials for Electric Machines

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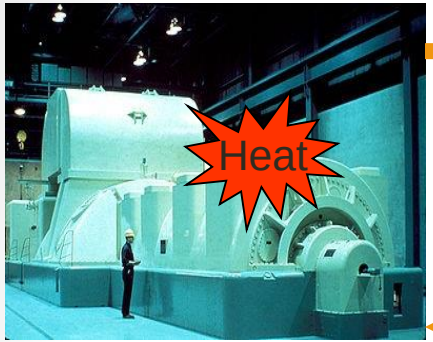
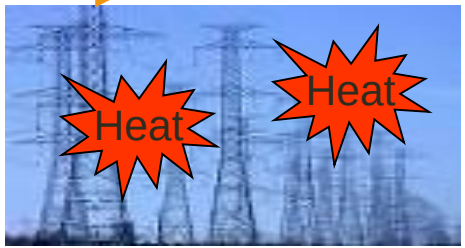
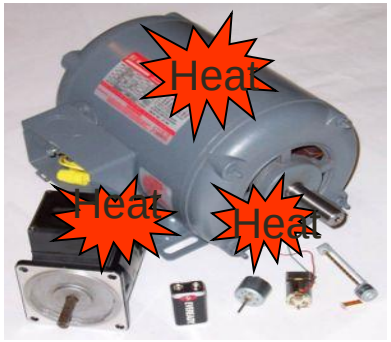
Electrical Conductors and Energy Loss by Resistive Heating



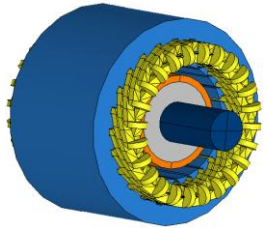
Electric power generators



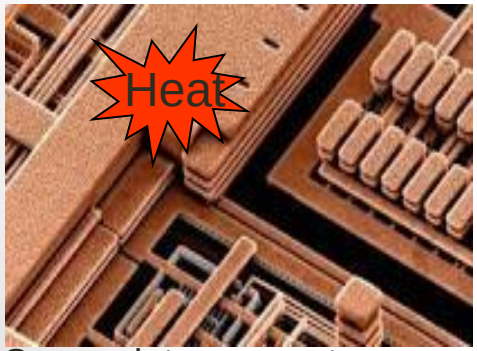
Electric power grid



Various motors and their applications



Copper windings



Copper interconnects

Electrical cables

Computers

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Issues about Conductors

- Currently Cu or Al are main players
- Resistivity of Cu is 1.7μΩ/m, Al is 2.7μΩ/m
- Joule (resistive) heating $Q=I^2Rt$, proportional to I and R
- Electric machines' efficiency is proportional to the current I, large current densities are preferred
- Large current wastes more energy due to Joule heating
- More heating needs more energy for cooling
- Thermal mechanical a threat for reliability
- How to increase the thermal and electrical conductivities at room temperature?

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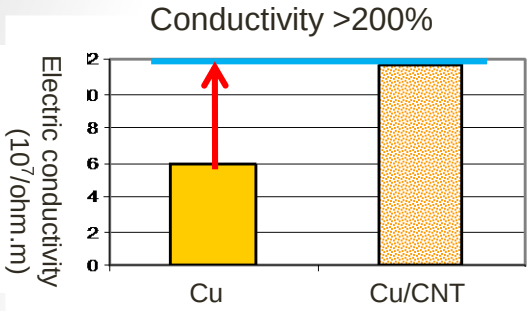
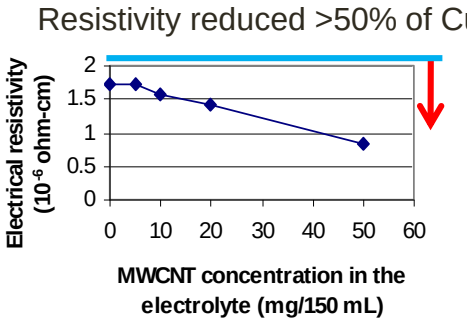
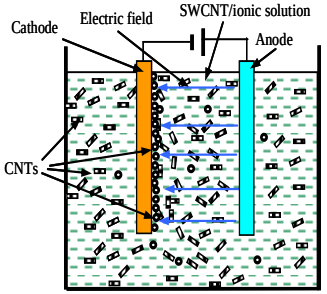
Performance of Ultraconductive Copper/CNT Nanocomposite



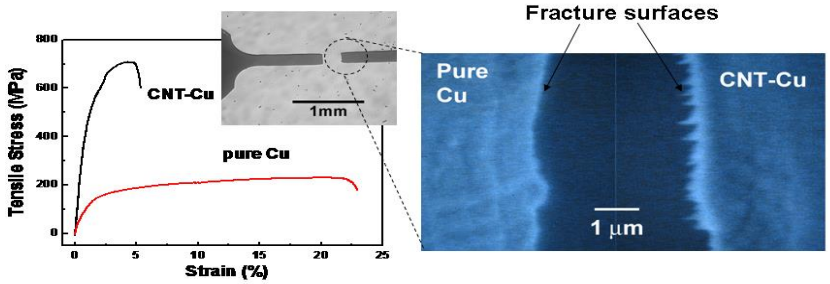
Comparison of electrical conductivity



Resistivity vs. CNT concentration



Cu/CNT fabrication



Tensile testing of Cu/CNT

- Conductivity is 200% of copper
- Strength >300% of copper
- Thermal conductivity >180% of copper
- Addition of CNT<1%
- Cost of Cu/CNT < 4% more of copper

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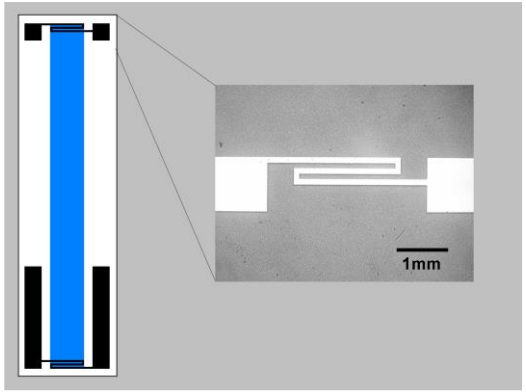
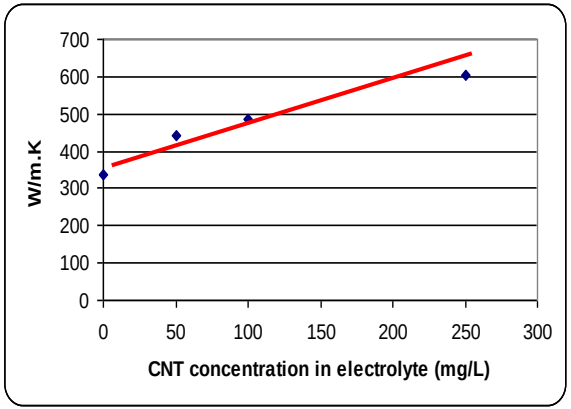
Thermal Conductivity of Cu/CNT



Schematic diagram of the thermal conductivity measurement setup and an optical image of the Pt heater



Thermal conductivity of Cu/CNT versus CNT addition in electrolyte (actual CNTs in Cu/CNT is < 1%)

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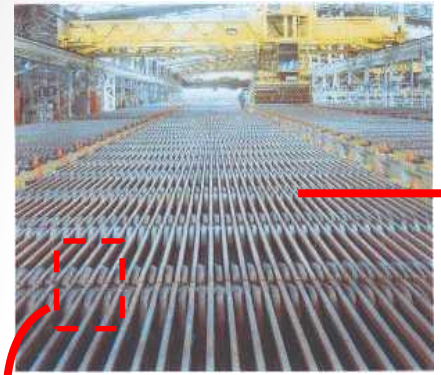
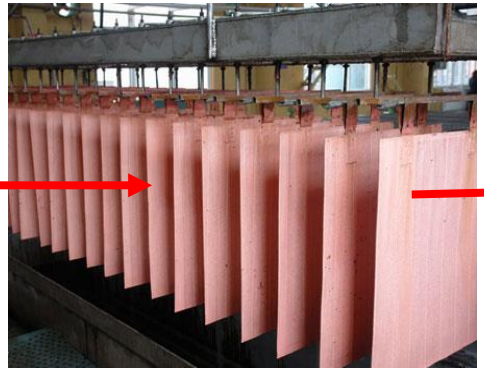
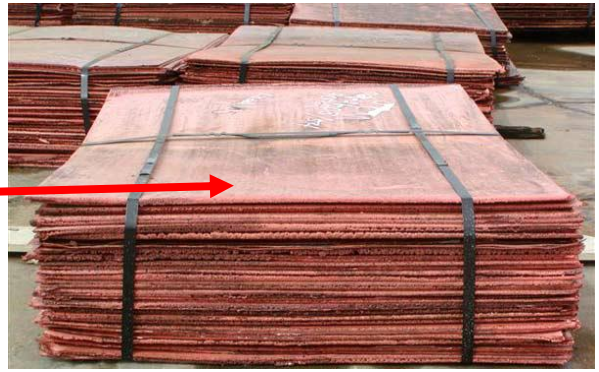
Designed for Manufacturing Scale-up



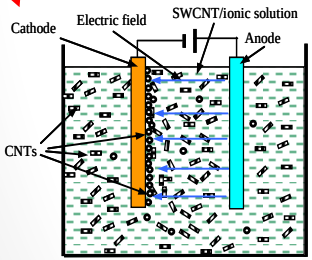
Today's standard copper refining is electrochemical



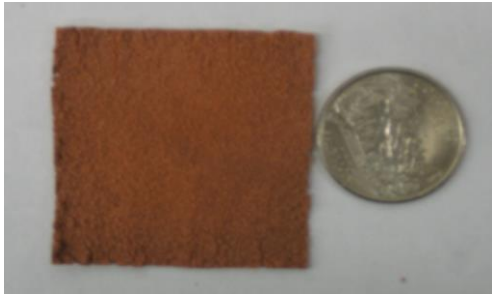
Copper cathode deposited



Copper plates removed from cathodes



Schematic of single co-deposition cell



Copper/CNT plate at UCF

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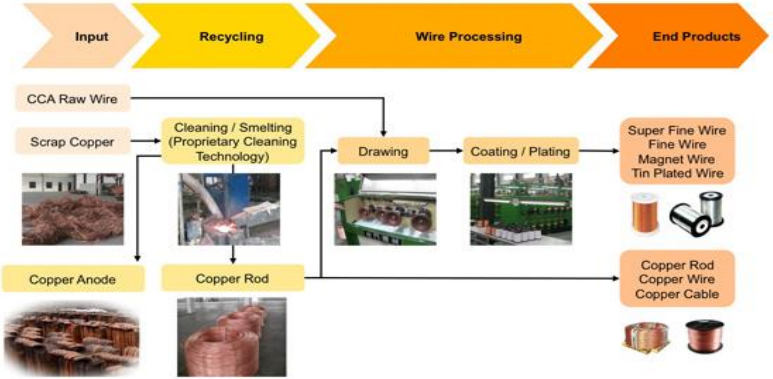
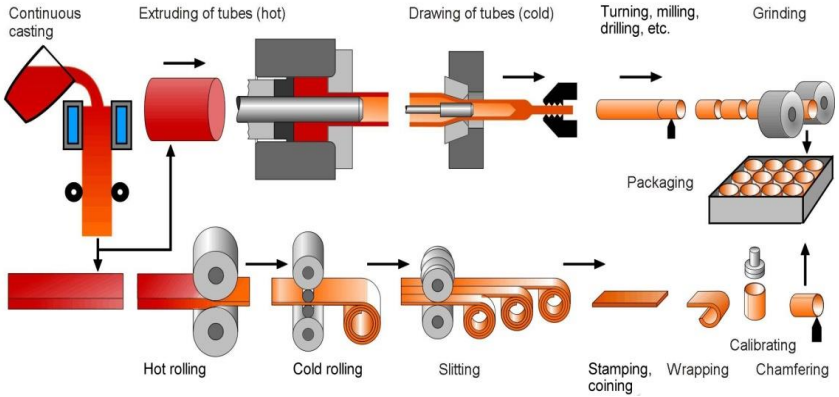
Manufacture of Wires and Cables

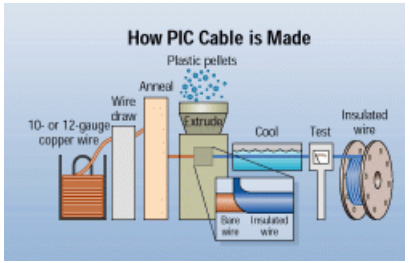
Solid round shape wire conductors

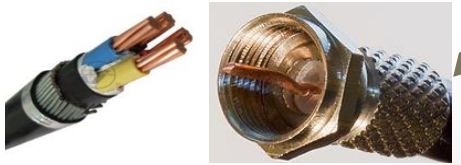


Other shaped conductors



The manufacturing process from casting to the finished machined and wrapped bushing





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Thank you for your attention!

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