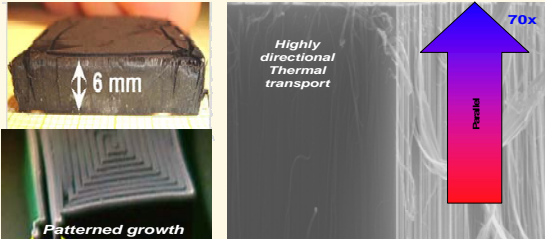


# Thermal Management Using Carbon Nanotubes

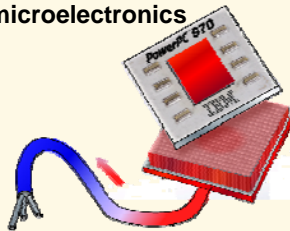
## Thermal Management Solutions: New Class of Nanostructure Thermal Interface Materials

### Vertically Aligned Carbon Nanotubes



### Potential Applications

#### Cooling of microelectronics



#### Structural Cooling Systems

### Summary

Optimal thermal management, especially in such cases as microelectronic packaging, requires thermal interface material with high heat carrying capacity. Although individual carbon nanotubes exhibit high thermal conductivity, aggregate forms of nanotubes lose this property due to processing that results in their aggregation.

Scientists at ORNL have developed vertically aligned carbon nanotube arrays that yield extremely high thermal properties. The array can be vertically aligned multi-walled, double-walled, few-walled or single-walled carbon nanotubes. The nanotubes are spaced at optimal distances from one another to minimize thermal transfer losses thereby maximizing their collective thermal diffusivity. The growth rate of these vertically aligned carbon nanotube arrays can be adjusted and measured thereby providing a method of control over array fabrication. The method also includes annealing treatments to increase the crystalline properties of the vertically aligned carbon nanotubes.

### Advantages

- High quality low cost nanostructured thermal interface materials
- High thermal conductivities (600-1200 W/mK)
- Anisotropic thermal properties
- Zero thermal expansion, flexibility of nanotube arrays enables efficient thermal contact on thermal cycling
- Thermal interface stability up to 750 C in air
- Ability to be combined with conductive pastes, polymers, or resins
- Conformable surfaces for good thermal contact to materials
- Can be fabricated into specific shapes, patterns density and heights directly during manufacturing

### Patents

- Fabrication of high thermal conductivity arrays of carbon nanotubes and their composites (UTB ID 1487) – [patent pending](#).

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