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Nanopackaging: Hype, Hope, or Happening?

CNT applications for packaging

Fujitsu Laboratories Ltd.

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Applications of CNTs

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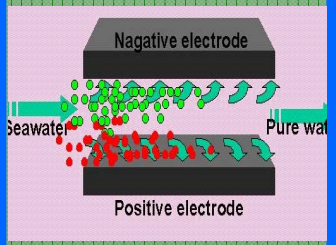
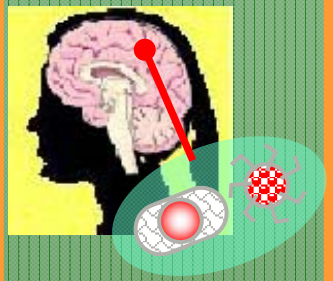
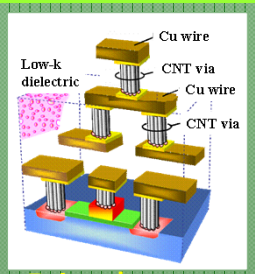
	Composite	Environment	Energy	Bio・Medical	Electronics
Feature	・Light-weight and high-strength ・High thermal conductivity	・Large surface ・Low cost	・Large-surface ・Light-weight	・Nano-structure ・Hollow-structure	・Nano-structure ・High-current density ・High-strength
Application	 ・High-strength composite、 ・Thermal -paste ・NEMS, etc.	 ・CO_2 adsorb ・Nano-filter	 ・Fuel cell ・Buttery ・Capacitor	 ・Bio-sensor ・Drug-delivery	 ・Display ・LSI interconnect

Bike, Racket using CNTs

Features of CNTs

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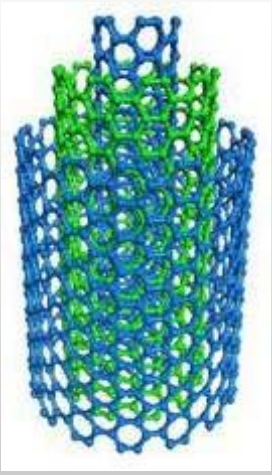
Single-walled CNTs

Multi-walled CNTs



- Electron mobility (semiconductor):
  ~ 100,000 cm^2/Vs (Si ~450 cm^2/Vs)
- Current density (Current handling capability):
  > 10^9 A/cm^2 (Cu ~ 10^6 A/cm^2)
- Thermal conductivity:
  ~ 3000W/m·K (Cu ~ 400W/m·K)
- Mechanical strength:
  ~ 1000 GPa (Cu ~130GPa)

Grown CNTs

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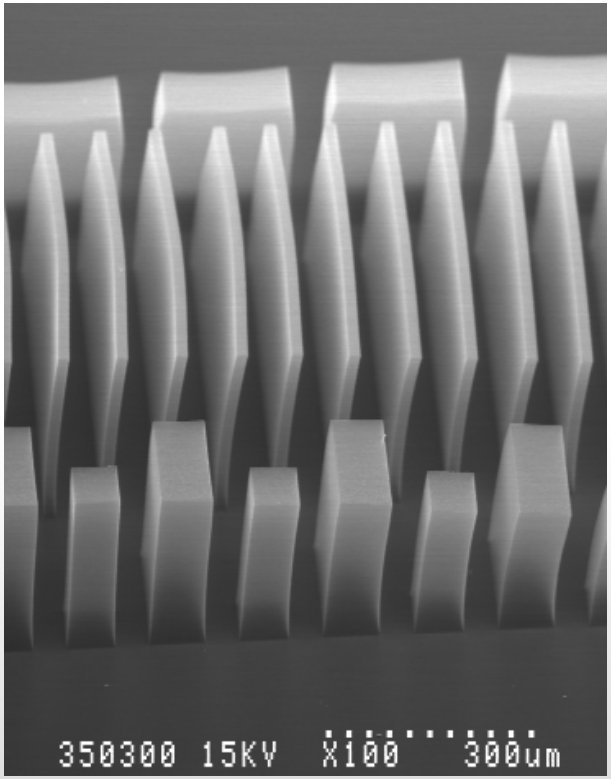
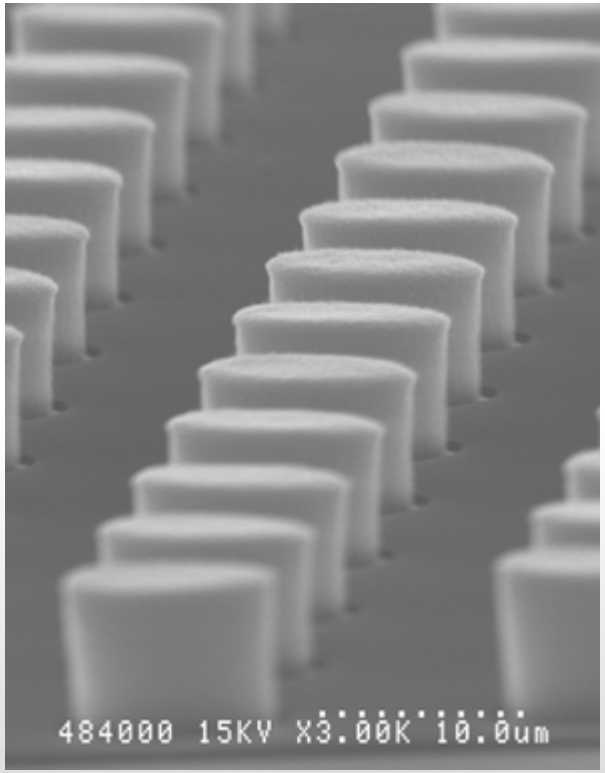
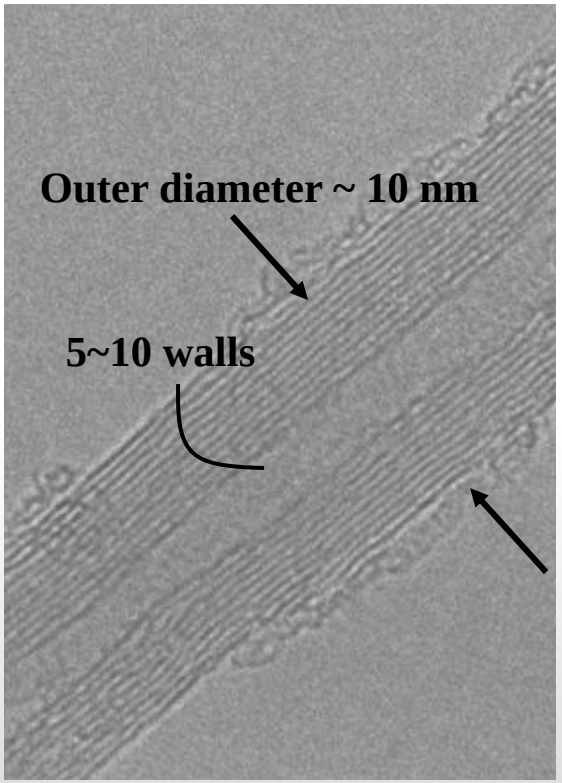






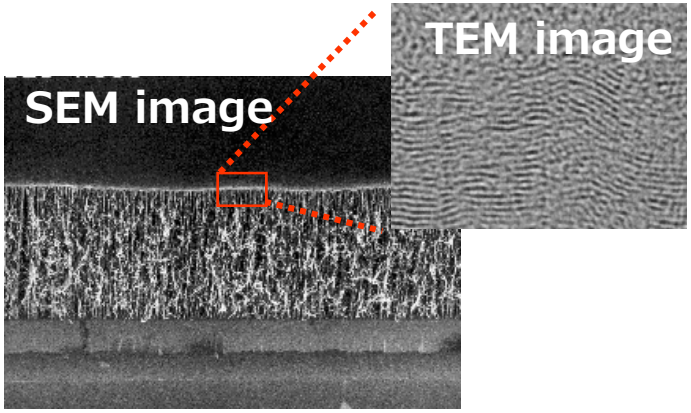
SEM image of CNT bumps:
A bump consists of millions of CNTs

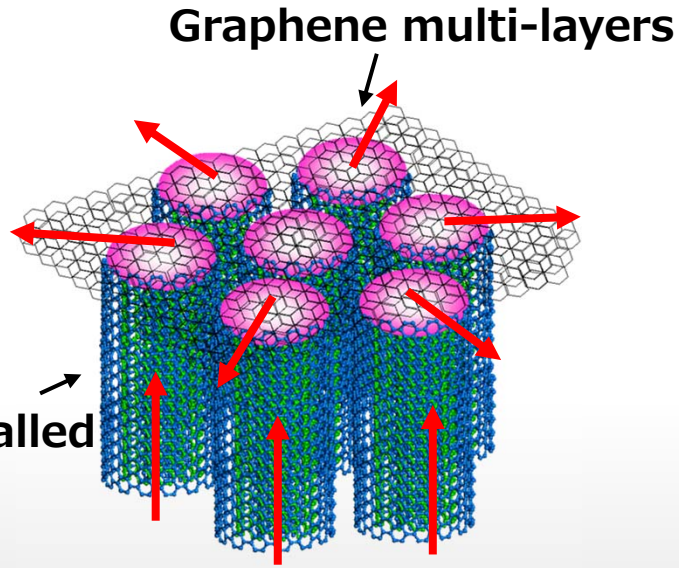
TEM image of CNT

Site density 3%: very important when thinking application

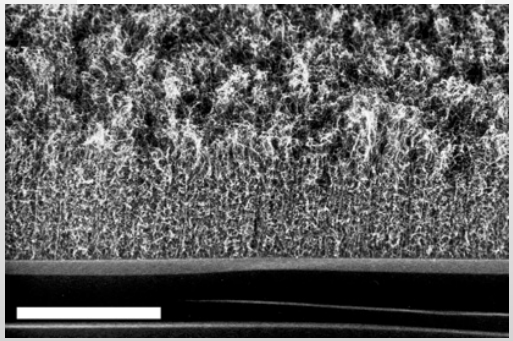
Nano-carbon composite structure

Nano-carbon composite structure





CNTs



Self-assembly of nanotube-graphene composite structure

Can conduct electricity and heat in vertical/horizontal directions

Interconnect technology 1:

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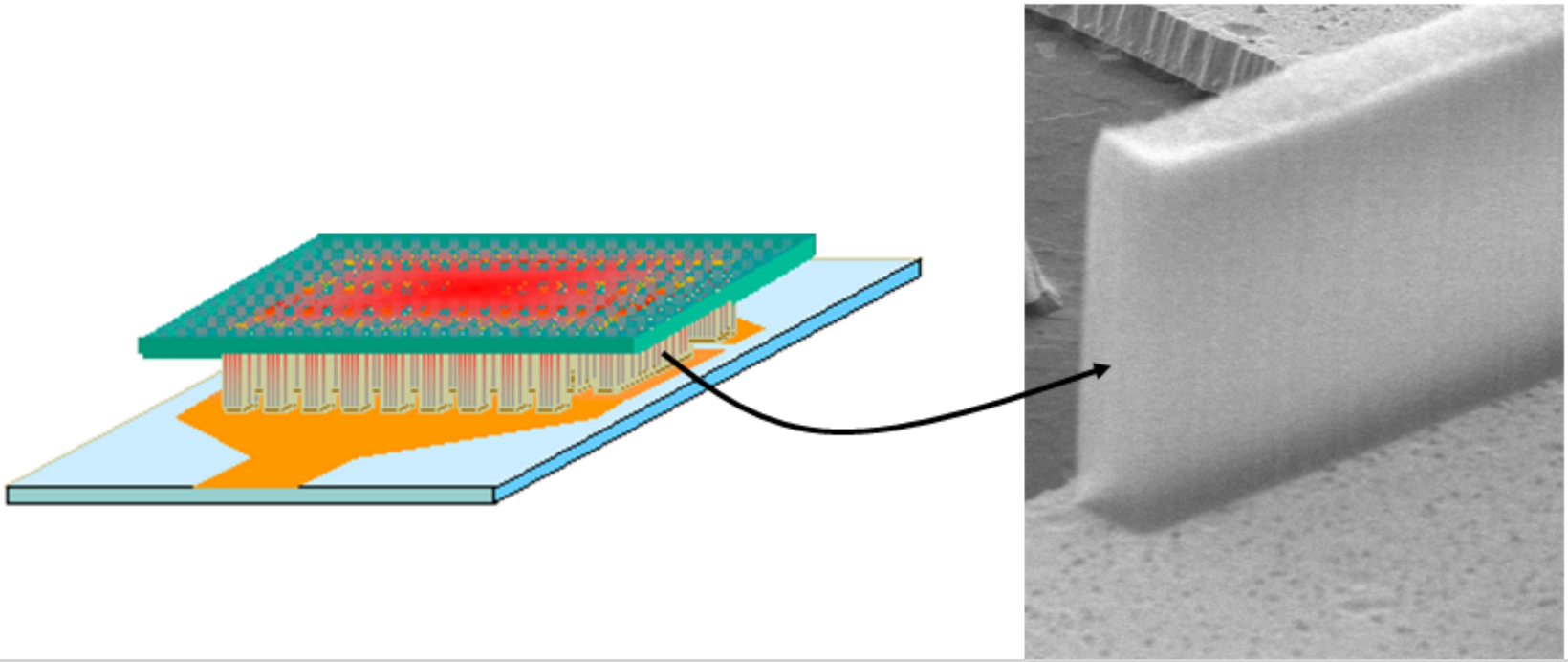
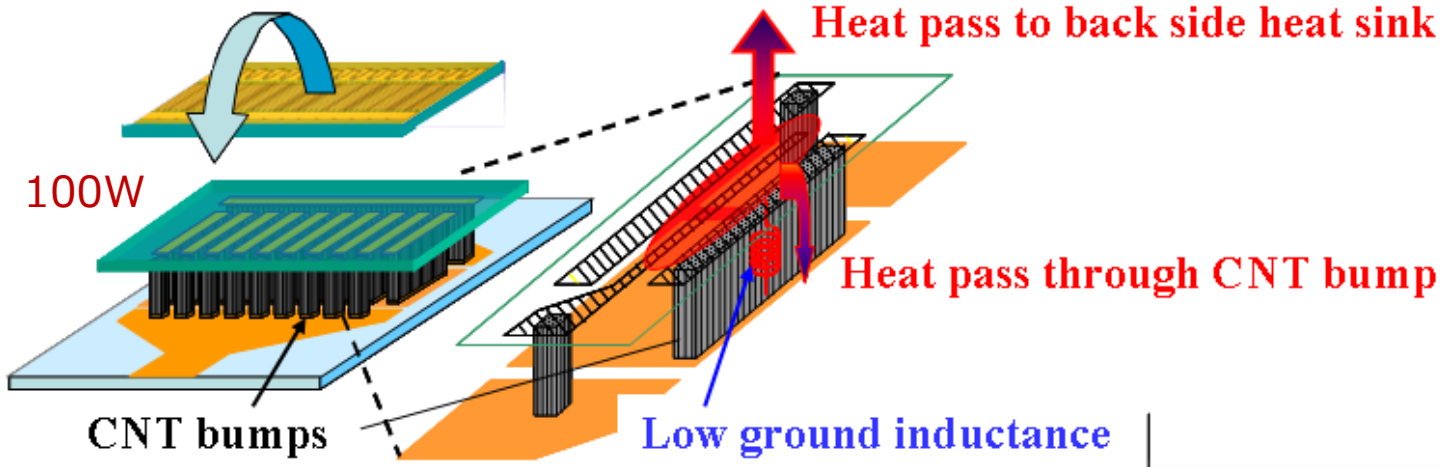
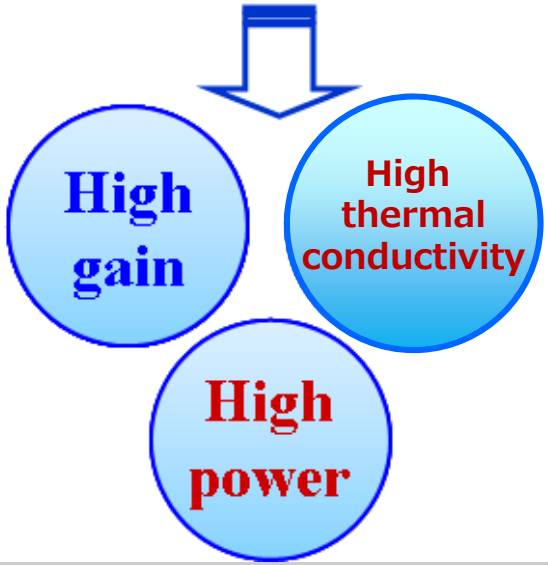
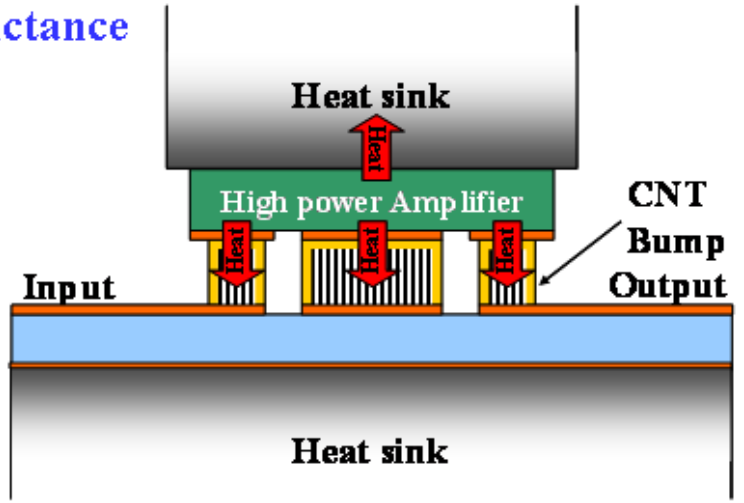
Flip-chip high power amplifiers for base stations utilizing CNT thermal conductive bumps



Flip-chip HPA with CNT bumps







Dual-side heat structure

Interconnect technology 2:

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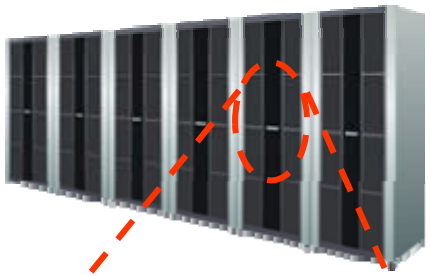
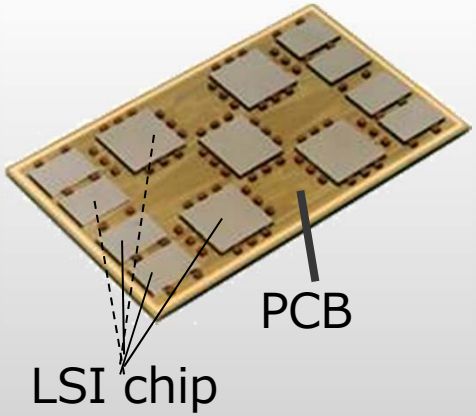
CNT flexible bumps for LSI modules

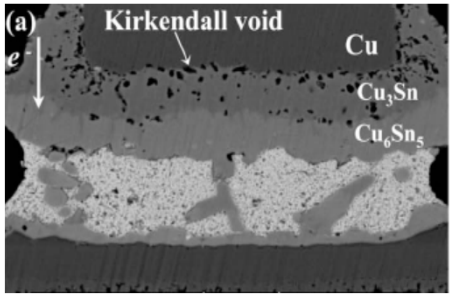
Server



LSI module

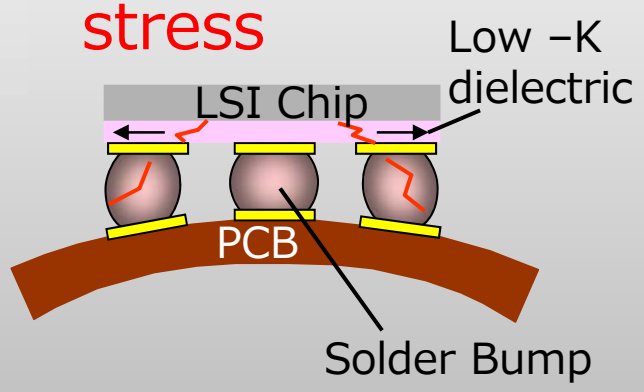


-Electro migration

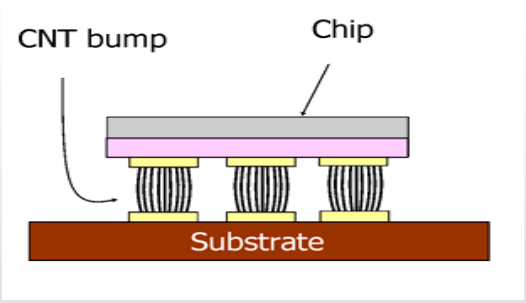


* J.-W. Nah *et al.*, J. Appl. Phys., 100 (2006) 123513

-Thermal-mechanical stress



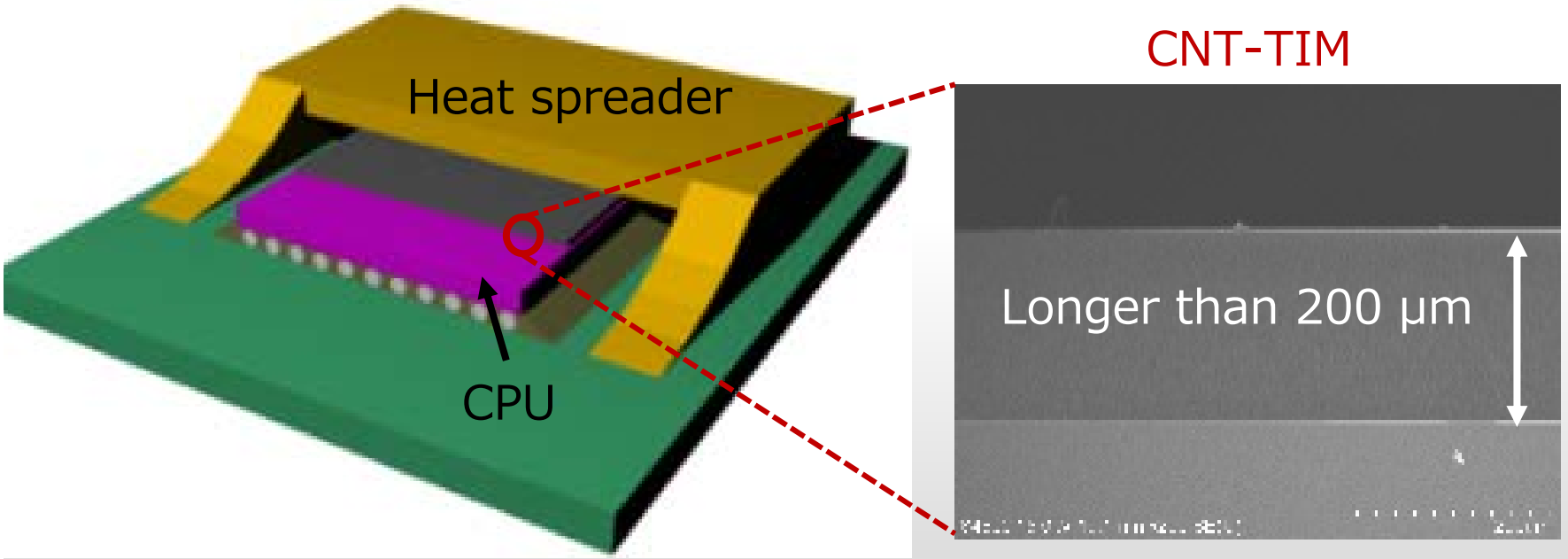
Solution:
CNT flexible Bumps



- No electro migration
- Stress free

Interconnect technology 3:

CNT Thermal Interface Materials



Target specification: Indium-TIM's properties

Brief summary

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To realize nanopackaging products using CNTs

- Material quality

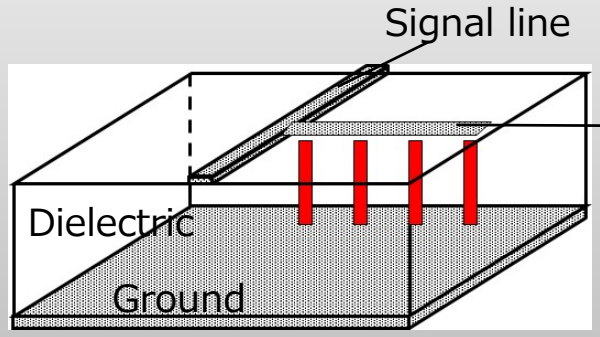
  will be acceptable, depending on applications

- Site density

  is very important to leverage the CNT's useful properties.
  will be acceptable for some application, TIM?
  also affects interface.

- Interface treatment between CNTs and the others

  is most serious issue to be solved for almost all applications.
  capacitance coupled passive components will be another direction



Stub with capacitive coupled CNT bundles
(will realize much smaller passive components)

Conclusion:

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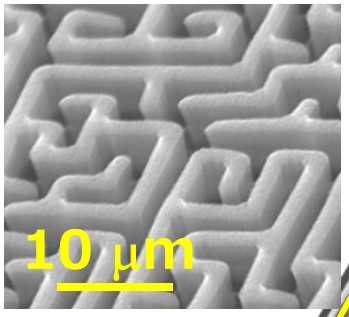


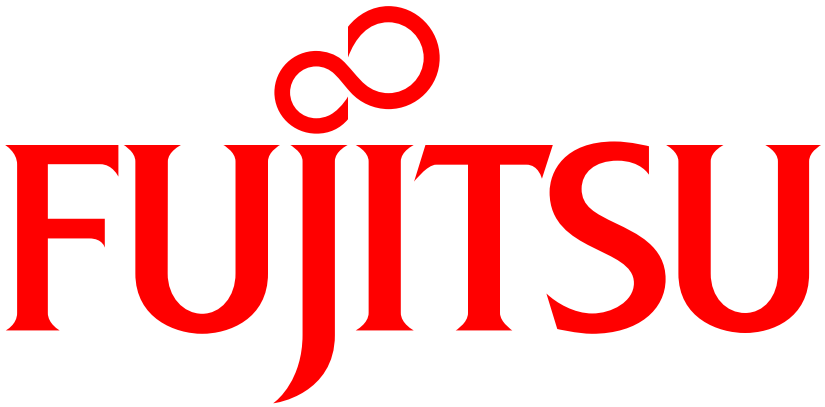
In ’90s

Entrance:
Carbon Nanotubes

Attractive properties
were “Hope”
at the same time,
were “Hype”

Exit:
Nanopackaging Products

Happening in next ECTC?



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