# Nano-Scale Heat Transfer Properties

MAE 284

Wilson Lam

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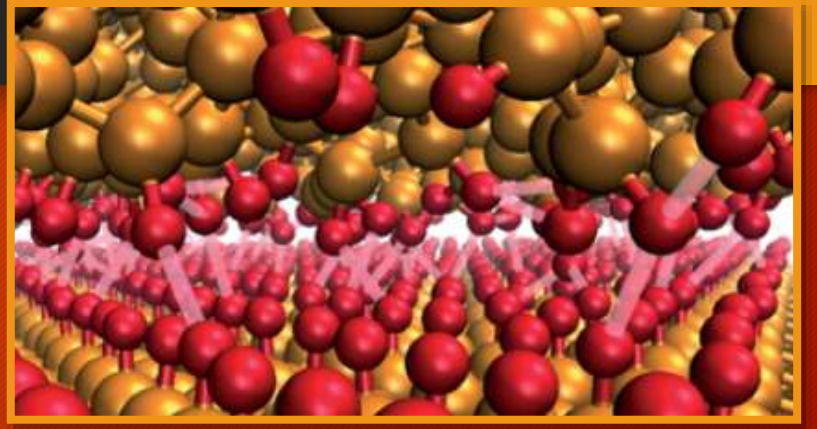
# Nano-Scale Heat Transfer Outlines

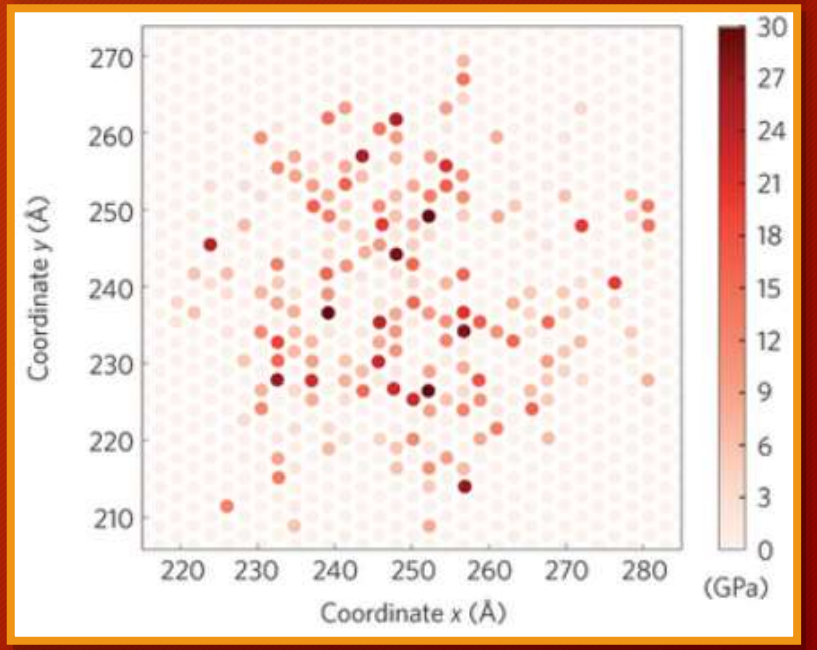
- The size effects on the phonon and electron transport change the heat transferring significantly when compare to macroscales.
  - Surface contact at nanoscale becomes 1-dimensional channels (atomic-level contact points).



[1]

- Size effects:
  - Cause by particle and wave properties of phonons
  - This cause Fourier Law to fail by classical and quantum size effects.

- This size effect on nanostructures and potentials of highly efficient thermoelectric (TE)
  - Nanostructures: Thin fims, Superlattices, and Nanowires

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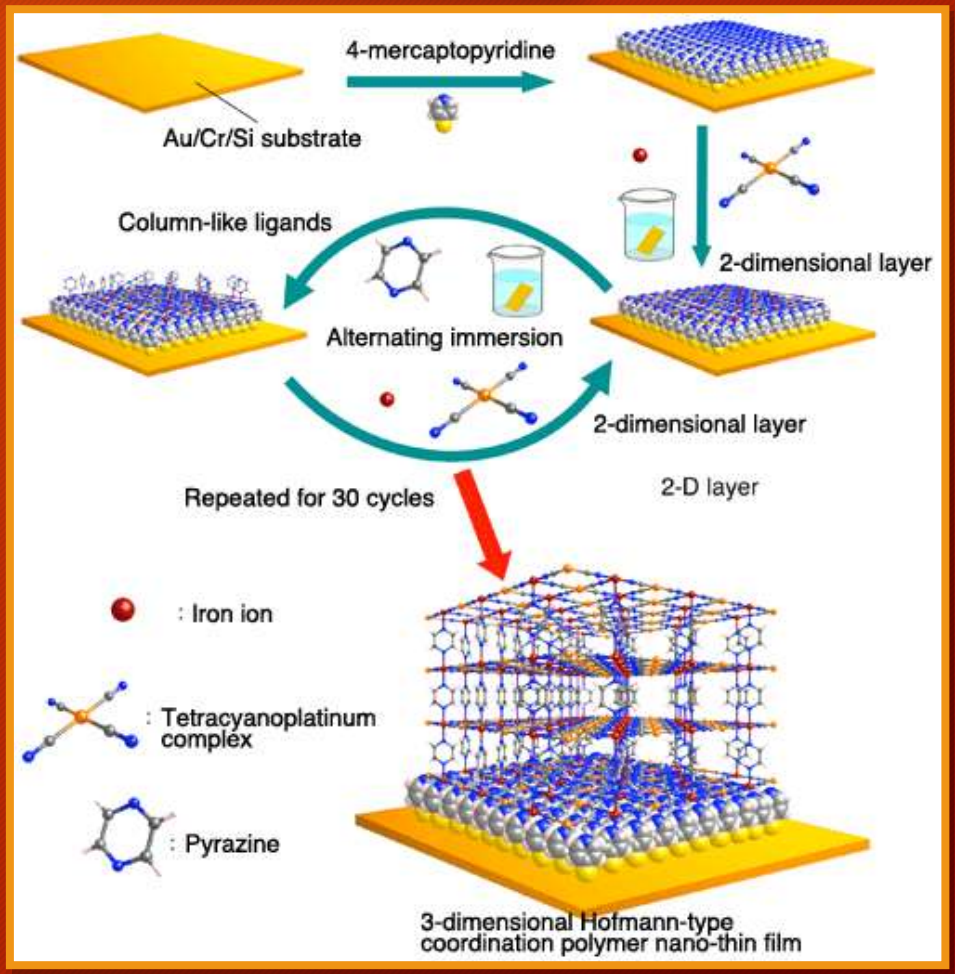
# Thin films

- Thin films heterostructures that have many materials layers may interferes with heat transfer
  - mean free path and film thickness will determine whether the phonons be scattered more frequently or not
- The interface of thin films may have a specular effect in which it will reflect the phonons wave back trapping the heat in the interface.

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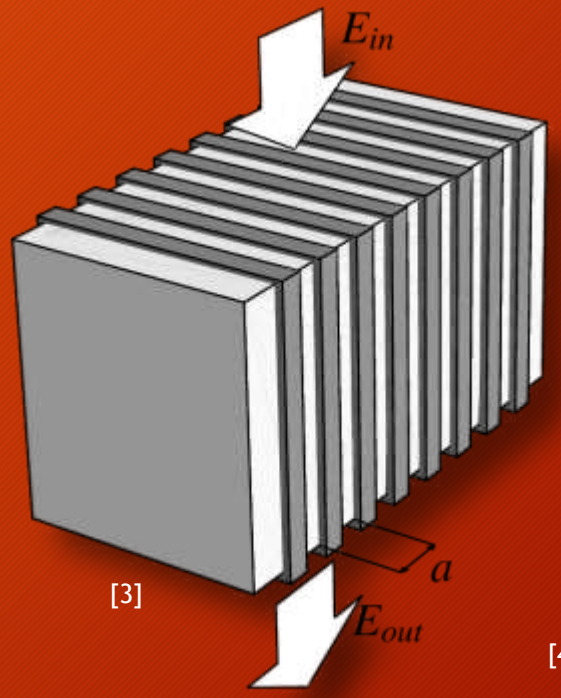
# Superlattices

- Superlattices impacts on device temperature rise.
  - Multilayer thin films of superlattices create additional thermal resistance.
  - Increased boundary scattering of heat.
- Phonons properties in superlattices
  - Lower thermal conductivities
  - Phonons wavelength is schatter in the lattice leading to higher temperature.

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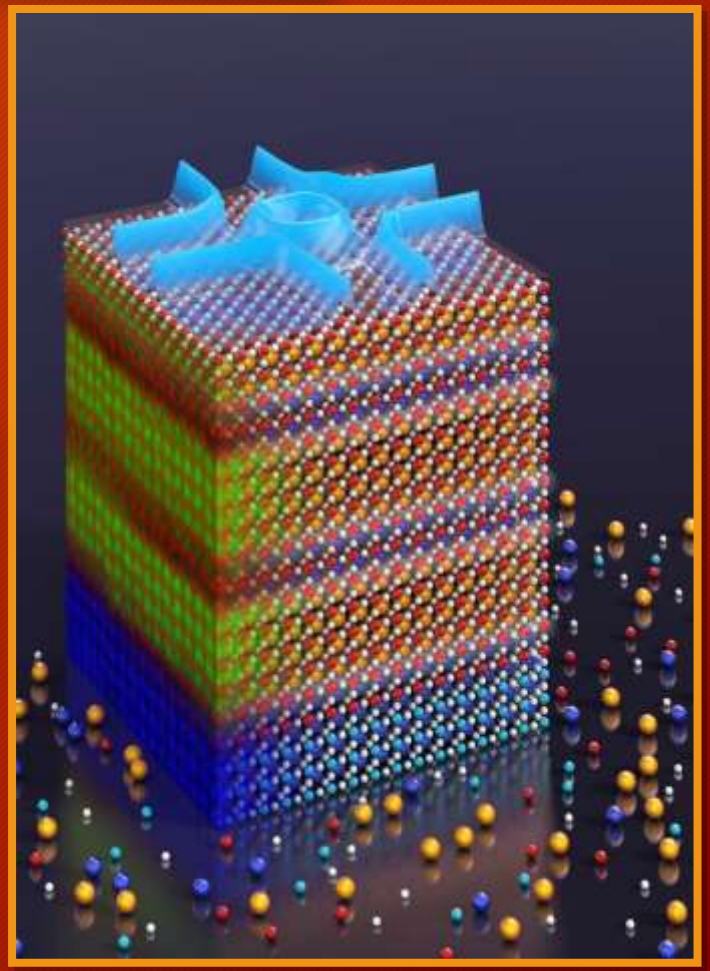

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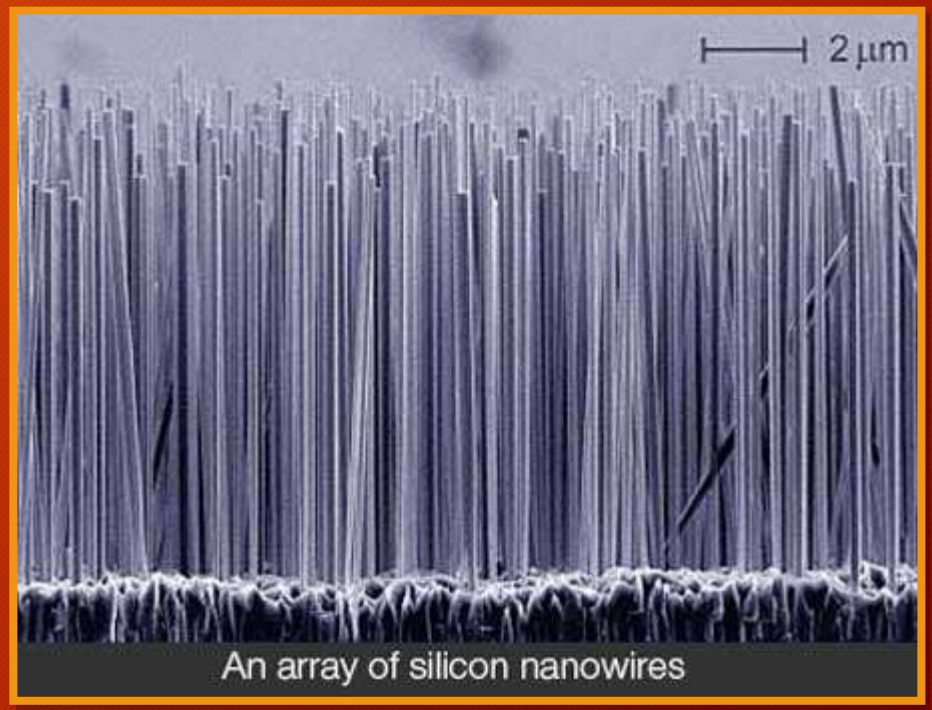
# Nanowires

- Nanowires are nanostructures with diameter of nanometer to tens of nanometers
  - Nanowires may be insulating, semiconducting, and metallic.
  - Possibilities of making more powerful solar cells.
- Interest in nanowires heat transfer is in the axial direction
  - During experimental conditions thermal conductivity for nanowires can be higher than diamond.



An array of silicon nanowires

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# Thermoelectrics (TE)

- Govern by the Thermoelectric Effect:
  - Seebeck effect
    - converts temperature to current
  - Peltier effect
    - current to temperature
  - Thomson effect
    - cooling and heating of current carrying conductor that has a temperature gradient
- This technology is relatively new and hold potential to future developments.

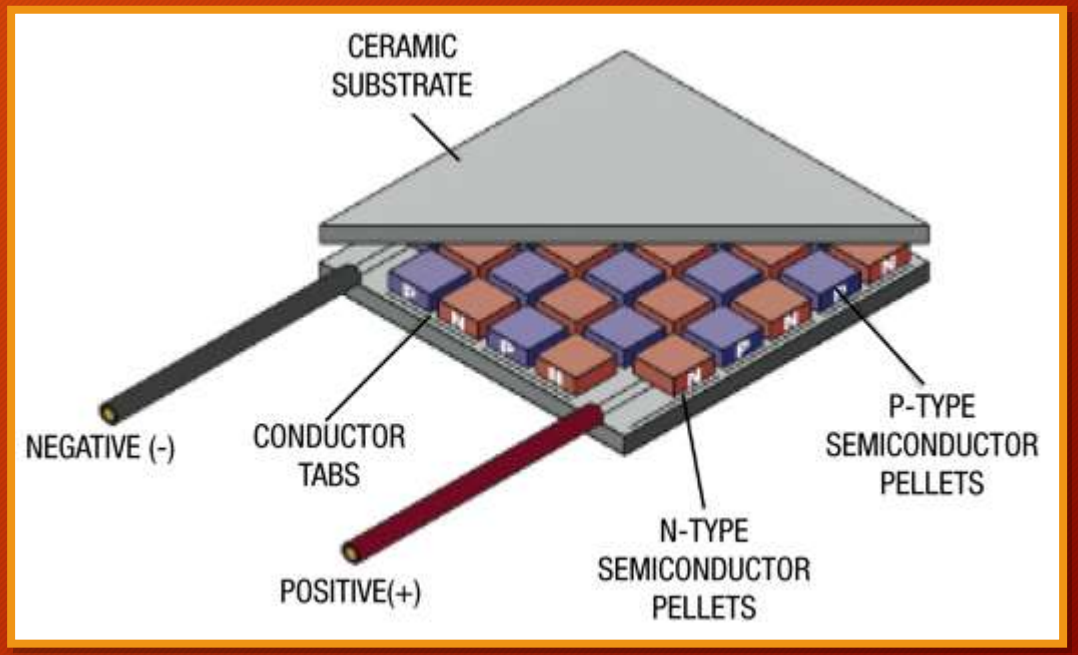


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Image Obtain from the following sites:

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