Mesoscale Priority Research Direction

(Thin Boundary Layer Heat Transfer)

Opportunity

Understanding heat transfer in boundary layers is the key to the effectiveness of many thermal technologies. In particular, at high flow speeds boundary layers become thin and possibly turbulent, but an ever present laminar sub-boundary layer is a bottleneck for heat flux. As is similar for larger scale structures, breaking up the sub-boundary layer can lead to higher heat flux.

Approach

Structures that are just 5-50 microns can break up the continuum (laminar) flow that prevents transverse energy transfer, and induce transverse convection. Gas-Solid heat transfer occurs at the atomic scale. Structures in the 5-100 nm range, smaller than the mean free path of the gas, have the promise of enhancing heat transfer without much dissipation.

Meso Challenge

What are the right scales and geometries to take advantage of these possible heat transfer enhancements? What are the materials and surface structuring techniques that would work at sizes 3 orders of magnitude apart that could scale to make useful heat exchangers and other thermal management tools for the least cost?

Impact

The interplay of continuum size and atomic size structures is a great physics challenge. Successful results will lead to novel fabrication techniques, possibly new composite materials, and finally highly optimized thermal transfer tools that could have a great impact on cooling nanoscale devices, CPU chips, Li–ion batteries and eventually impact many other thermal management problems.

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