# Using Fractal Architectures for Enhancing the Thermal-Fluid Transport

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**Abstract :** Enhancing heat transfer in compact volumes is a challenge when constrained by cost issues, especially those associated with requirements for minimizing pumping power consumption. This is particularly acute for electronic chip cooling applications. Technological advancements in microelectronics have led to development of chip architectures that involve increased power consumption. As a consequence packaging, technologies are saddled with needs for higher rates of power dissipation in smaller form factors. The increasing circuit density, higher heat flux values for dissipation and the significant decrease in the size of the electronic devices are posing thermal management challenges that need to be addressed with a better design of the cooling system. Maximizing surface area for heat exchanging surfaces (e.g., extended surfaces or "fins") can enable dissipation of higher levels of heat flux. Fractal structures have been shown to maximize surface area in compact volumes. Self-replicating structures at multiple length scales are called "Fractals" (i.e., objects with fractional dimensions; unlike regular geometric objects, such as spheres or cubes whose volumes and surface area values scale as integer values of the length scale dimensions). Fractal structures are expected to provide an appropriate technology solution to meet these challenges for enhanced heat transfer in the microelectronic devices by maximizing surface area available for heat exchanging fluids within compact volumes. In this study, the effect of different fractal micro-channel architectures and flow structures on the enhancement of transport phenomena in heat exchangers is explored by parametric variation of fractal dimension. This study proposes a model that would enable cost-effective solutions for thermal-fluid transport for energy applications. The objective of this study is to ascertain the sensitivity of various parameters (such as heat flux and pressure gradient as well as pumping power) to variation in fractal dimension. The role of the fractal parameters will be instrumental in establishing the most effective design for the optimum cooling of microelectronic devices. This can help establish the requirement of minimal pumping power for enhancement of heat transfer during cooling. Results obtained in this study show that the proposed models for fractal architectures of microchannels significantly enhanced heat transfer due to augmentation of surface area in the branching networks of varying length-scales.

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