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Micro oscillating heat pipes for thermal management in high energy physics and space applications

Thermal management represents a major challenge in both high energy physics (HEP) and space missions. Whether it is to dissipate the heat generated by readout chips and other electronic components or to extend the service life of silicon sensors, cooling has become one of the main design concerns in both fields. Furthermore, the harsh environmental conditions encountered in both outer space and HEP experiments impose severe constraints, as the cooling solutions must operate under vacuum and absorb significant radiation doses. Continuous advances in micro-engineering have opened the door to the development of smaller and more efficient cooling devices capable of handling increasing power densities with a minimum mass penalty. In this respect, previous work carried out at CERN has focused on the use of micro-channels etched in single crystal silicon (ScSi) wafers to circulate a cooling fluid. However, whilst this technology represents an appealing solution for thermal management in detector modules, it poses a number of challenges, particularly for high fluid pressures and long staves. Among these, the brittle nature of ScSi, the lack of suitable interconnections and the difficulties for the integration, packaging and qualification of such devices hinder their application in areas where reliability is paramount.

This research project aims to address these issues, developing high conductivity, radiation hard devices that meet the requirements of HEP experiments and space missions. Attention should be paid to improve the existing solutions for interconnections while reducing their number, creating either independent cooling circuits or closed loop devices which exchange heat with secondary cooling lines. The research would not be necessarily restricted to ScSi, and flexible materials (e.g. pyrolytic graphite) could be also investigated. Both traditional micro-fabrication methods and novel additive manufacturing techniques would be combined to tackle the problem.

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