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DESIGN AND ON-BOARD VALIDATION OF PUMPED TWO-PHASE FLUID LOOP FOR HIGH
HEAT FLUX REMOVAL

Abstract

Directed energy weapons, wide band gap semiconductor based radars, and other powerful systems present significant thermal control challenges to thermal designers. Heat Flux levels approaching 500 W/cm² are encountered at the base of laser diodes, and levels as high as 250 W/cm² are expected in laser slabs and power amplifier tube collectors. These impressive heat flux levels frequently combine with strict operating temperature requirements to further compound the thermal control problem.

A cooling system consisting of pumped two-phase fluid loop and diamond micro-channel is present to meet the requirement of heat removal for high power payload in space, such as laser and radar. In this paper, flow-boiling is investigated on Earth as well as in reduced gravity space experiments using ammonia as working fluid. Cooling capacity as high as 271 W/cm² is verified in space experiment. This cooling system works very well with a two-phase accumulator to control the temperature of micro-channel heat sinks.

In two-phase system, large density differences between liquid and vapor create buoyancy effects in the presence of a gravitational field. Such effects can play an important role in two-phase fluid flow and heat transfer. It is found that high coolant velocities can combat the detrimental effects of reduced gravity in space systems. This proves existing data, correlations, and models developed from 1g studies can be employed with confidence in designing reduced gravity thermal management systems, provided flow velocity is maintained above a limit.