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Optimizing the Next Generation of Heat Sinks for Immersion Cooling: Think, Print and Test

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Extended Abstract

As the number of electrical and electronic systems increases, their physical sizes decrease, and the spacing between electrical components decreases, both the total amount of heat generated (hence to be dissipated) and the power density (the heat generated per unit volume) increase significantly. There is a general agreement in the scientific community that current air-cooling technologies are asymptotically approaching their limits imposed by available cooling area, available air flow rate, fan power, and noise. Boiling can be a very efficient heat transfer mechanism, thus it can be used to maintain the junction temperature of electronics devices at values compatible with the technology using compact heat sinks. Immersion cooling is considered a promising thermal management technique for the next generation of high heat flux electronics components and devices. However, the geometries of the heat sinks commonly proposed for this application are not specifically optimized and, in general, are simply taken from simple standard solutions. This implies that, on one hand, the boiling heat transfer might not be maximized and, on the other hand, that the amount of material and the volume of the heat sinks might be greater than the optimized solutions. Both these issues are critical especially in the immersion cooling where the volume and the distance between the electronic components must be minimized. This work focuses on the optimization of heat sinks for immersion cooling and it aims to demonstrate that the standard geometries are far away from the optimal solutions for this kind of application. Through an intensive and fruitful International collaboration between NHTlab at University of Padova (IT), CTRC at Purdue University (US), and the Mechanical Design lab at INFN (IT), novel heat sinks were designed and optimized through a dedicated algorithm, then the best solutions were manufactured in copper via 3D metal printing and, finally, tested during pool boiling in dielectric fluid. The results demonstrate that, with a simple optimizing algorithm, it is possible to design extremely efficient and compact, heat sinks for immersion cooling paving the path for the next generation of thermal management systems.