MASTER

Jet impingement cooling for 5G and radar applications

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Public abstract of the Master Thesis

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Abstract

New generation radar systems and 5G communication systems are associated with a high heat dissipation per Integrated Circuit (IC), of which a large number are present on an antenna. Therefore, the need arises for a cooling solution that keeps the junction temperature T_j of an IC under 358 K, that can maintain temperature uniformity within 1.5 K between neighbouring heat dissipating elements and while operating at a maximum pressure drop of 4 bar. This study focuses on laminar and turbulent single phase indirect submerged water jet impingement cooling for thermal management of heat dissipating elements. The performance of the jet impingement cooling solution was assessed by means of an axisymmetric conjugate heat transfer numerical model of a single transitional impinging jet, a 3D conjugate heat transfer numerical model of three inline laminar, transitional and turbulent impinging jets in parallel crossflow orientation and an experimental setup of an 4x3 array of laminar impinging jets, in which thermocouple probes were embedded for temperature sensing. Maximum stagnation point heat transfer coefficient h_0 was 80.000 W/m^2K and T_j was 318 K in the axisymmetric numerical model, when $Re = 2520$. In the 3D numerical model, T_j was 320 K and the maximum temperature difference between neighbouring heaters ΔT was 0.2 K, when $Re = 4700$. Moreover, the location of the stagnation Nusselt number Nu_0 was displaced in upstream direction due to jet deflection. Furthermore, the value of Nu_0 was 55 % higher in the third impingement zone due to non-uniform fluid distribution. Based on the experimental results, the approximated junction temperature was 318 K and the thermal resistance to the chip junction R_j was estimated at 3.6 cm^2K/W, when $Re = 141$. The temperature difference between neighbouring heaters was 1.9 C, which exceeded the allowable value. Moreover, the pressure drop through the experimental setup was 1.18 kPa, which is 0.295 % of the total pressure drop budget. The stagnation Nusselt number agreed well between the data of the axisymmetric numerical model and the 3D numerical model when $34 < Re < 1000$. When $Re > 1000$, however, the data between the two numerical models significantly differed. The stagnation Nusselt number based on the experimental data was significantly lower compared to that of the numerical models. For future work, it is recommended to study the effect of crossflow and fluid distribution in a larger array of impinging jets. Moreover, it is recommended to study the applicability of conventional liquid cooling, as highly laminar jets yielded a satisfactory heat transfer coefficient.