Design of a Heat Trap for Optimal Heat and Current Conduction on Soldering Pads

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Electronic circuit boards often need the use of heat traps on many of their soldering pads, like ground or high current lines, to make the automated soldering process possible.

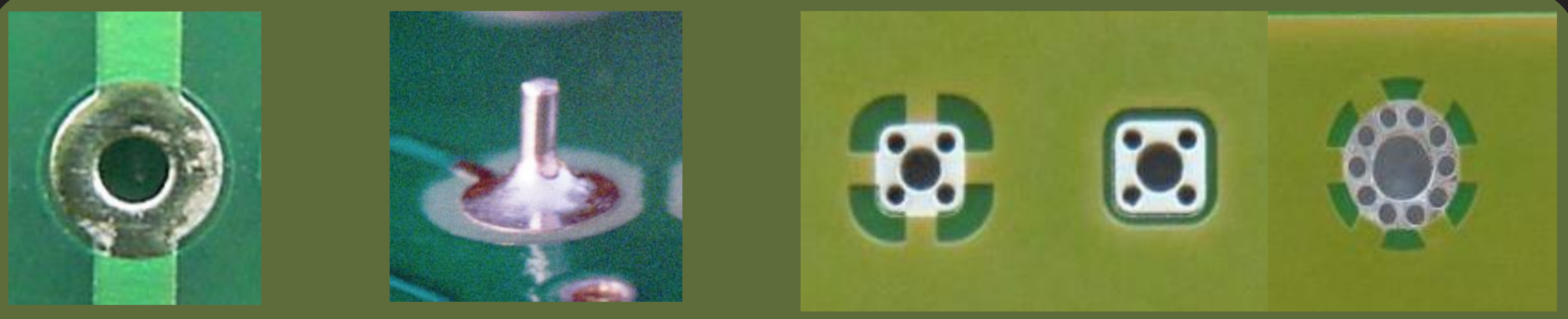

Figure 1. Soldering Pad, with Pins and heat traps

The aim of this work is to optimize a soldering pad with a heat trap that allows the soldering process, and at the same time assures the best electrical conductivity diminishing the generation of excessive joule heating.

Making use of the heat transfer module in COMSOL, it was possible to model the heat dissipation during the soldering process in transient state, as described by *eq.1*, and the generation of joule heating by the maximal designed current capacity flowing through the pin and soldering pad, described on *eq.2*.

$$\lambda\nabla^2 T + q_V - C_p\rho\frac{\partial T}{\partial t} = 0 \qquad \text{(eq. 1)}$$

$$\rho C_p\frac{\partial T}{\partial t} = \nabla(k\nabla T) - \rho_b\omega_b C_b(T - T_b) + Q_m + \sigma\left|\nabla V\right|^2 \qquad \text{(eq. 2)}$$

Through a series of parametric sweeps, two heat trap designs were simulated, letting a current of 5[A] through the pin to the copper layer, allowing us to compare the behaviour of each geometry in terms of heat generation when modifying the length of the holes that define each heat trap.

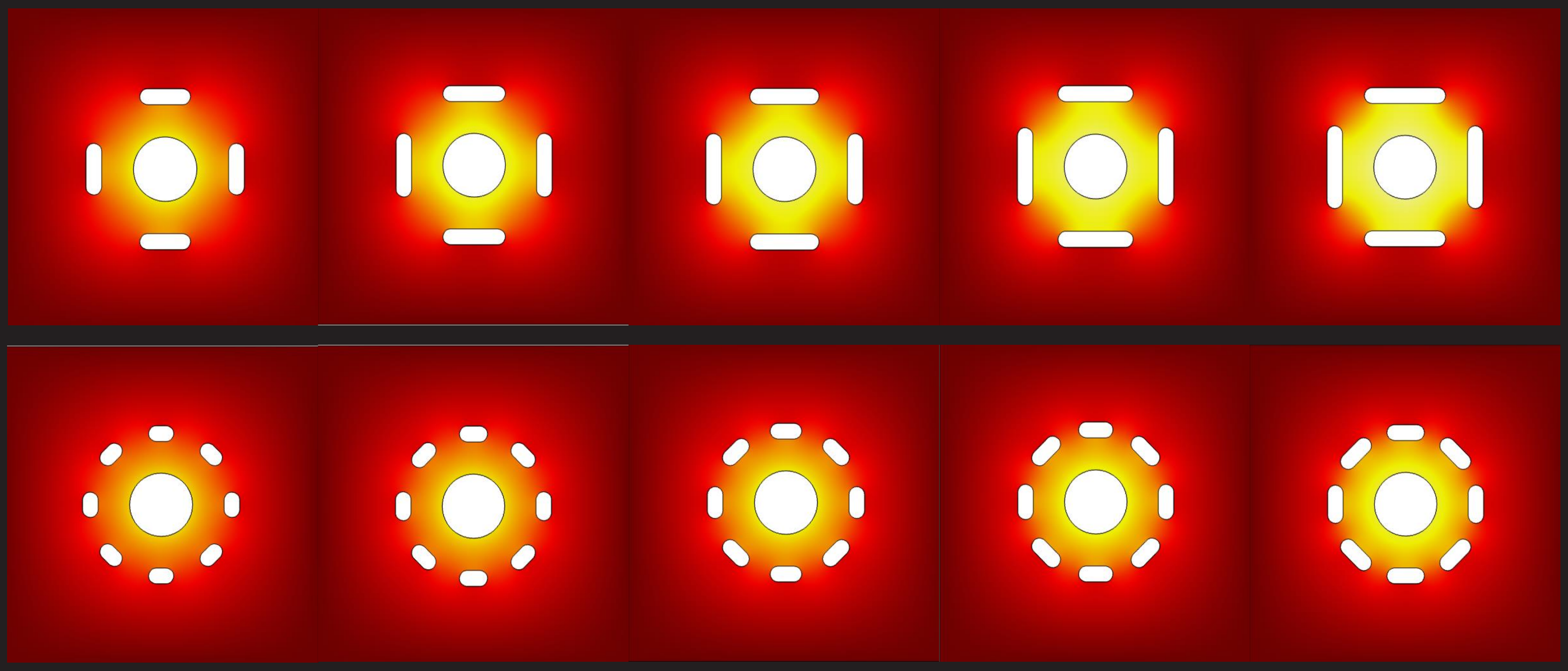

Figure 2. Stationary Joule Heating for both tested geometries when changing the hole lengths that define the heat traps

It is possible to clearly notice the temperature rise when increasing the holes length around each pad.

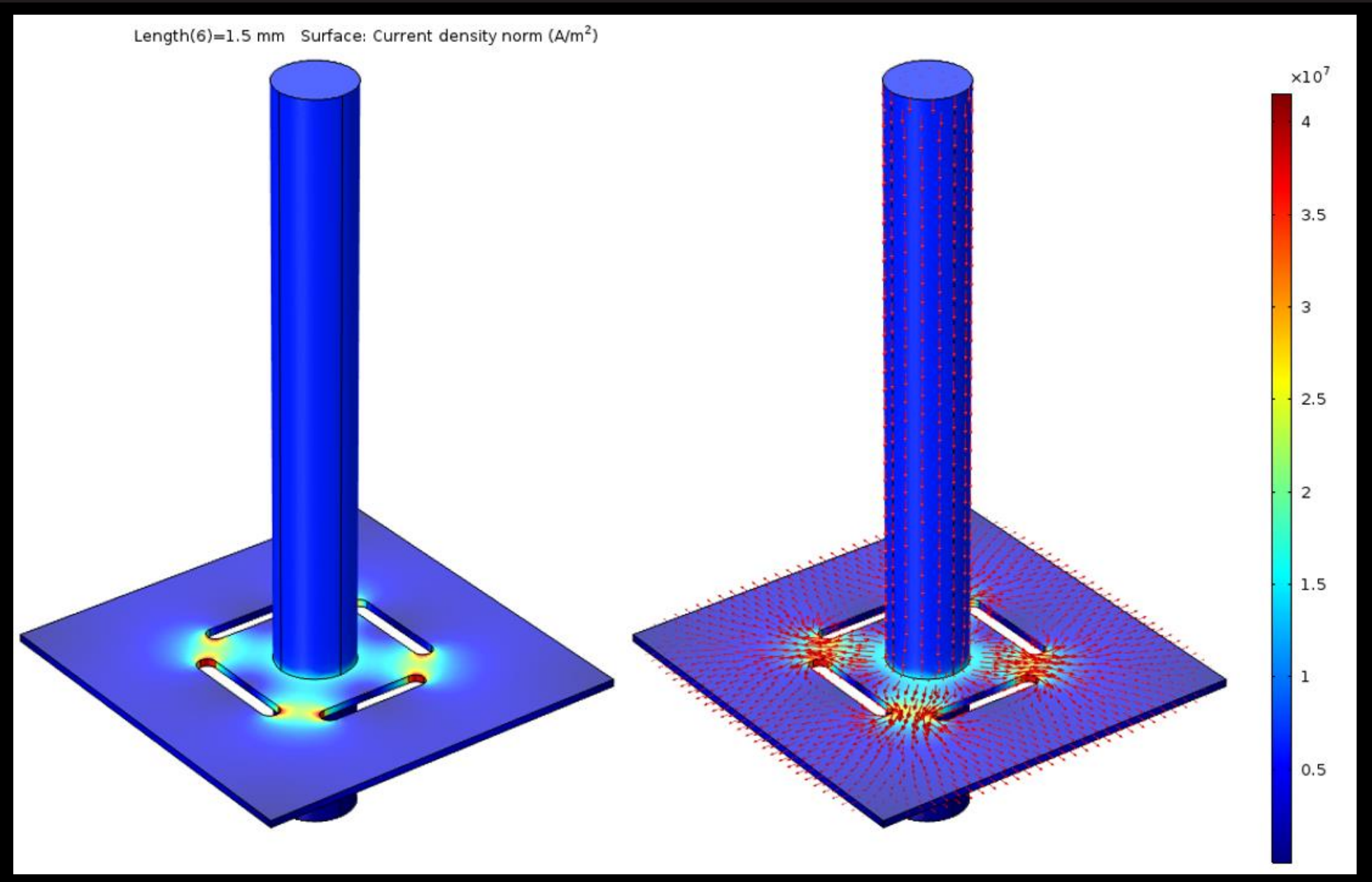

Figure 3. Current density generating Joule heating through a pin in a soldering pad

A following series of simulations was realized comparing both studied heat trap geometries, and a third soldering pad without heat trap, to show the process of heating and cooling in transient state.

From the parametric sweeps, the curves of temperature difference inside the heat traps as the holes length increases, can be seen in figure 4.

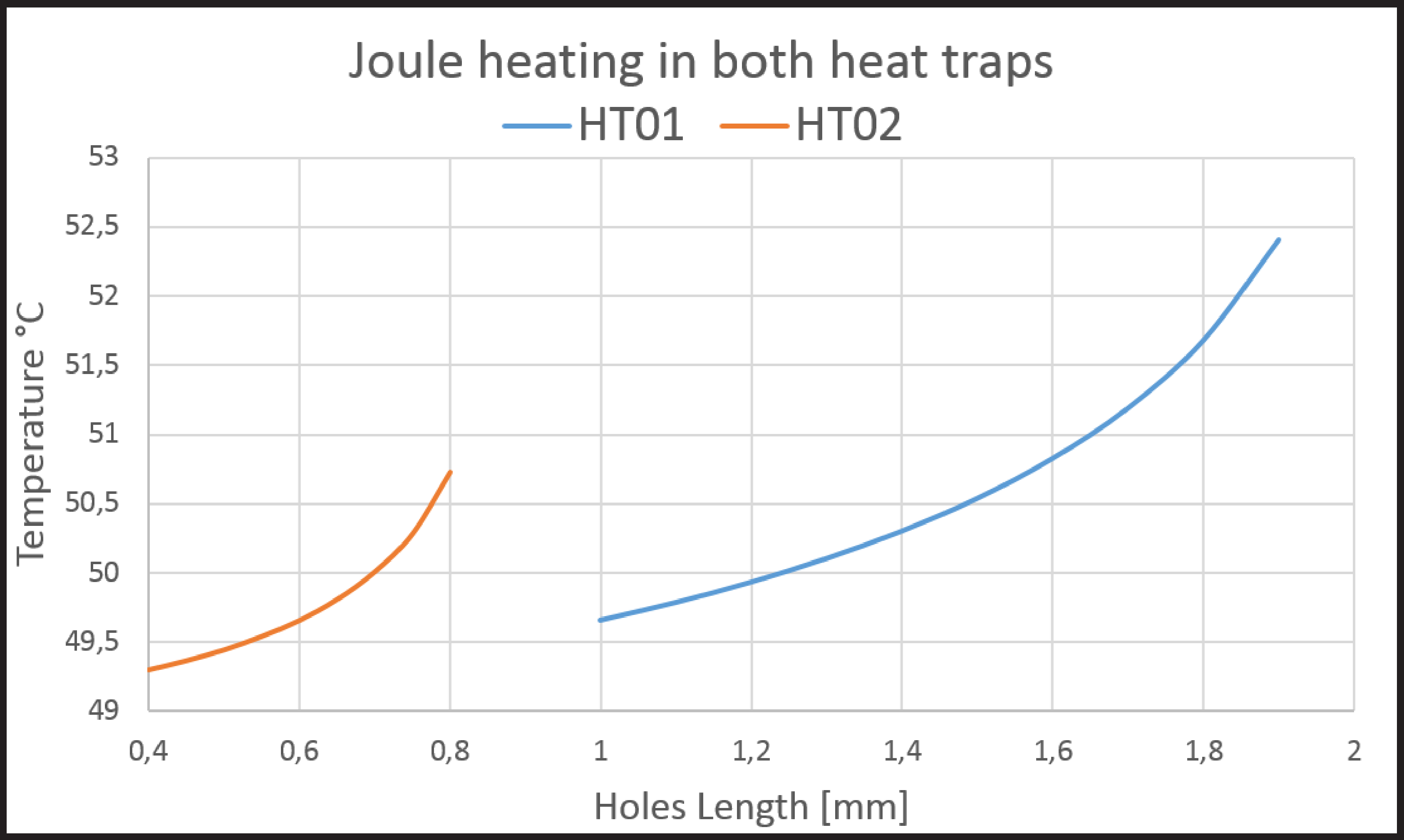

Figure 4. Steady state simulation results: Temperature variation for both heat trap types

The next diagram shows the heating and cooling of the three simulated pads after the soldering process. In this process, the circuit board comes in contact with the liquid tin-solder for a few seconds, filling the pads completely for the later cooling and hardening of the metal.

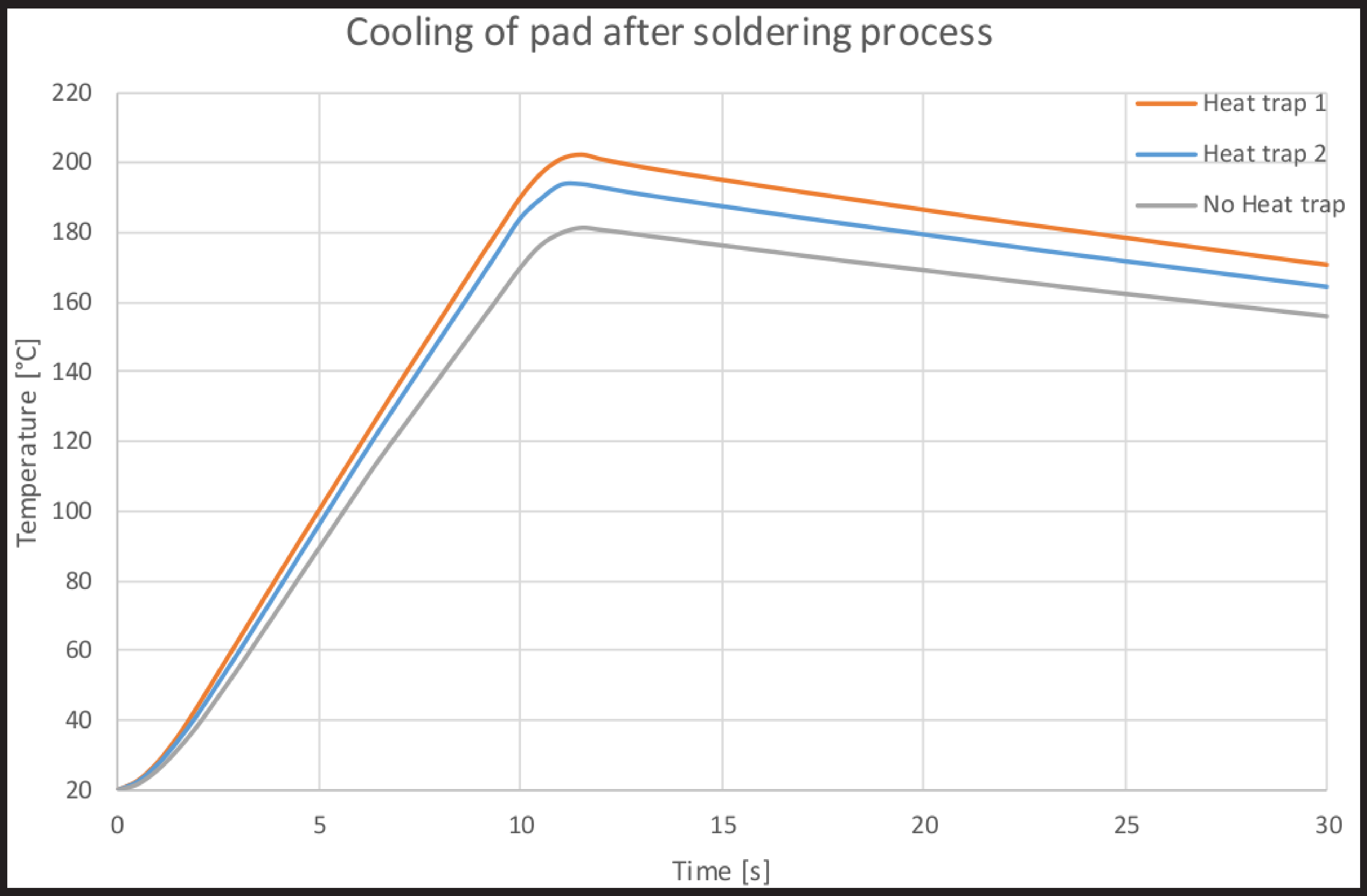

Figure 5. Transient for the three studied soldering pad cases by heating and cooling

The soldering process requires a minimal temperature of 183°C for the tin solder to reach the melting point. Without a heat trap it would be necessary to apply higher temperatures and longer soldering times, what could easily damage the circuit board. On the other side, it must be taken into account that the current heat generation has to be held under certain limits. Both heat trap designs show to be adequate to fulfill these requirements, but the absence of a heat trap would hinder the production of a reliable circuit board.

References:

1.Erni Grice, Critical Factors in Thru Hole Defects (2013)
2.Comsol Multiphysics, Heat Transfer Module Application Library Examples (2015)

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