Effect of Large SMDs on Tombstoning during Vapour Phase Reflow Soldering

Attila Géczy, Dániel Szalmási, Balázs Illés

Department of Electronics Technology, Budapest University of Technology and Economics
Budapest, Hungary
billes@ett.bme.hu, gattila@ett.bme.hu

Summary: In this paper, the tombstoning failure is investigated during heat-level type vapour phase reflow soldering (VPS), where the heat transfer is based on condensation. Different measurements were performed according to different printed circuit board (PCB) test patterns, to investigate any "shadowing" caused by larger surface mounted (SMD) components, pointing to possible tombstoning failures either by condensate congestion or by vapour concentration dynamics. The basic concept was to intercept, whether a large power electronics component would affect the heating on nearby smaller chip-sized resistors, which are susceptible for such problems during VPS. Three test patterns were applied according to different component orientation. 0603 component matrix was designed around larger components in the center on printed circuit boards, where three cases were investigated: a 4036 large size SMD capacitor, an XAL1010 SMD inductor, and without large SMD, for reference. A sweep on the power settings was performed with a heat-level vapour phase soldering oven. Shear strength of the components were also evaluated. It was found that both the shear strength of the 0603 components and the occurring tombstone failures of the solder joints are affected rather by paste printing and positioning precision, rather than any shadowing caused by larger components.

Keywords: tombstone, reflow, vapour phase soldering, shadowing

Motivation and Description of Work

Vapour phase soldering is a non-conventional reflow method, where the heat transfer is based on condensation. During condensation soldering, the condensate of a heat transfer medium (Galden) is formed in filmwise manner. The effect of condensation is completely different compared to the conventional infrared-based radiation heating or the forced convection used in ovens for mass production. During condensation-based heat transfer, filmwise condensation is dependent on the concentration of surrounding vapours, also the condensate flows in a dominant direction, from center to edges on the top of the components, and overall on the printed circuit board substrate. The condensation causes a momentary drop in the vapour concentration around the [1] assembly – this is depending on the thermal capacity of the assembly, and the power of the heating during heat-level based VPS control (where the vapour is generated from the bottom up onto the assembly according to a given power setting). It was reported previously [2][3], that tombstoning failure is non negligible during vapour phase soldering.

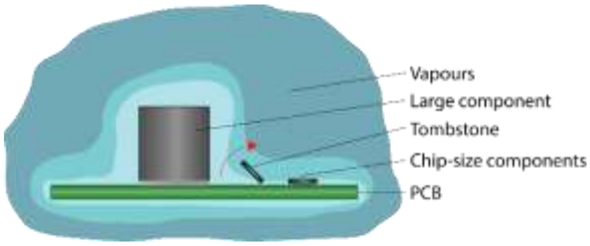

Fig. 1: Investigated situation, where the large SMD component affects vapour concentration as a "shadowing"-type effect.

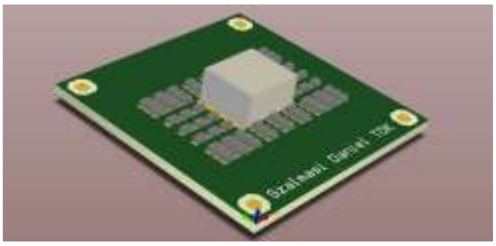

Fig. 2: One of the proposed test patterns with a 4036 capacitor in the center of a 0603 type SMD resistor matrix.

In this paper, the possible aspects of SMD component cross effect on condensation (shadowing – uneven vapour concentration around the assembly due to the large thermal capacity, as seen on Figure 1.) and resulting tests are discussed.

For the measurements, three different test PCB patterns were applied. The boards were assembled with a semi-automatic, batch type SMT line. The SAC305 solder paste was reflowed with Asscon Quicky 450 with Galden LS230. The most critical PCB test pattern was used for further analysis, where the heating power of the heat-level VPS was varied from 30% to 100%. Two components were selected to be positioned in contrast to 0603 chip size resistors: 4036 capacitor, an XAL1010 power inductor. The order of thermal mass can be three magnitudes larger on the inductor components compared to chip-size capacitors. Figure 2 shows one of the proposed test PCB patterns. The investigations were performed with optical and shear-strength analysis.

Results

Initial results show, that the shear strength does not depend on the relative position between the large and the small components, also, the shear strength values are not depending on the different design patterns of the carrier test PCBs (Figure 3). The results also point to casual tombstoning, as seen in Figure 4. According to the control measurements, it was found, that despite the thermal capacitance differences, the tombstoning effect can be traced back to the uneven paste printing, on misalignment in the positioning of the components. Thus, the condensation-based heat transfer of the heat-level vapour phase soldering can be reported as a process, which is not susceptible for shadowing-induced tombstone soldering failures.

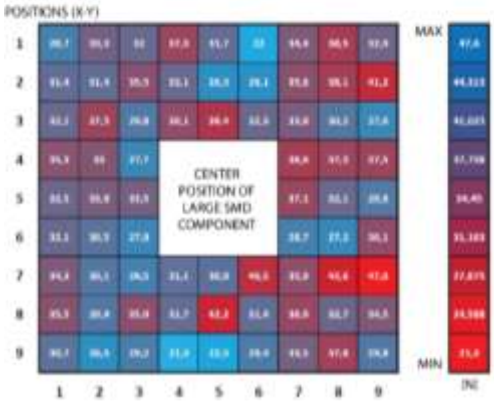

Fig. 3: Shear strength map of small 0603 components around 4036 capacitor

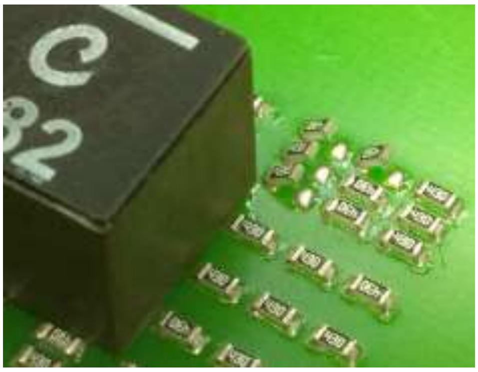

Fig. 4: Tombstone defects around a XAL1010 power inductor.

Acknowledgements

The paper and the research were supported by Bolyai János Research Scholarship and by the National Research, Development and Innovation Office – NKFIH, FK 127970. The work of Gergely Takács was appreciated.

References

[1] B Illés, A Géczy, Investigating the dynamic changes of the vapour concentration in a Vapour Phase Soldering oven by simplified condensation modelling, 2013. Applied Thermal Engineering 59 (1-2).

[2] Rudolf Strauss, "SMT Soldering Handbook" (2nd edition), BH Newnes, 1998.

[3] Ning-Cheng Lee, "Reflow Soldering Processes and Troubleshooting: SMT, BGA, CSP and Flip Chip Technologies", BH Newnes, 2002.