What are the benefits of soldering with vacuum profiles? – Part 3
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Introduction
After having described the influence of aperture variations and vacuum on the number of voids and void content in BTCs (bottom terminated components) in parts 1 and 2, a further advantage of the targeted use of vacuum is shown in part 3. As a result of the uniform distribution of the vapor during the pre-vacuum phase, it was possible to significantly improve the 3-dimensional soldering process for a MID (molded interconnect device) application.

Use of MID Technology
MID technology is used in particular where significant miniaturization, freedom of design with regard to geometry and a reduced number of components for the electronics assembly is required. The electrical and mechanical features which are normally distributed to various components during conceptualization and development are combined into a single MID part. And thus an intelligent, energy-self-sufficient pressure sensor system with a MID housing was developed as part of the Joint Project for Intelligent, energy-self-sufficient couplings for fluidic systems for automotive applications of the German Federal Ministry of Education and Research (No. V3EAAS010). Figure 1 (left) shows the individual process steps required for LPKF-LDS® technology in the production of the interconnect device. Thanks to the MID housing, the sensor could be made very compact manner and with a reduced number of components.

Figure 1: The MID Housing Manufactured by LPKF-LDS® Technology (left) and the Vertically Distributed Mounting Levels of an Energy-Self-Sufficient Pressure Sensor (right)
Source: Intelligent, energy-self-sufficient couplings for fluidic systems for automotive applications (IEKU, No. V3EAAS010), German Federal Ministry of Education and Research
3D MID Package

Due to the three-dimensional design of the housing, the contact points between the interconnect device and the PCBs are vertically distributed (see figure 1, right). As shown in figure 2, the package was soldered in the worst possible position for vapor phase soldering, namely as a cup. In conventional systems, this type of component positioning leads to excessive carry-over of the vapor phase medium. This results in some solder joints being heated more quickly than others, loss of medium from the system due to the cup effect - and a negative influence on the soldering profile. In order to investigate this effect, a soldering test was first of all conducted using a standard vapor phase process with a lead-free temperature profile.

Soldering Test, Vapor Phase Process without Pre-Vacuum

As shown in figure 2 (left), thermocouples are attached to various internal mounting levels, as well as to the upper and lower edges of the housing. First of all, the temperature profiles were recorded on the component while injecting the Galden® at ambient pressure and followed by the main vacuum. The curves in figure 2 (right) make it apparent that the measurement results demonstrate considerable differences with regard to heat up times. The great differences observed with regard to the heat transfer on the component can be traced back to two causes: on the one hand, the vapor rising up from the bottom to top causes time-delayed heat energy input over the height of the housing and, on the other hand, the air from the lowermost areas cannot be fully displaced. These two effects influence the development of the temperature gradient over time, and thus the heat up behavior of the component as well.

Figure 2: Positioning of the Thermocouples and Alignment of the MID Housing (left), and Measured Temperature Profiles (right) During Vapor Phase Soldering only with Main Vacuum
Soldering Test, Vapor Phase Process with Pre-Vacuum

The next step of experimental investigation involved testing with the same component alignment and thermocouples positioning and the addition of a pre-vacuum step. Right from the very beginning of the soldering process, a pre-vacuum of 100 mbar was pulled and Galden® was directly injected into the vacuum. The measurement results depicted in figure 3 reveal a much more uniform temperature rise at various locations on the component, which enable a much more uniform transition into the liquidus phase at various component mounting levels.

Distribution of Galden® Vapor inside the Process Chamber

When vacuum is used, the Galden® Vapor is distributed uniformly throughout the process chamber instead of forming an ascending vapor front during preheating and soldering. In this way, the disadvantages of the temperature gradient associated with conventional vapor phase systems (the closer to the source of heat the sooner heat up takes place) and with convection systems (the closer to the source of heat the sooner heat up takes place and the hotter it gets) are avoided. This is due to the fact that there are not any large masses of air which have to be displaced, thus permitting quick distribution of the gas molecules into the “empty room”. This effect has a positive influence on the profiling of the soldering process and the temperature homogeneity during heat up, and finally on the quality of the soldering result!

Figure 3: Measured Temperature Profiles at Various Locations on the Component During Vapor Phase Soldering with Pre Vacuum and Main Vacuum
Summary

By using vapor phase soldering in combination with in-situ vacuum, geometry-related deviations in the temperature profiles can also be eliminated in addition to reducing void content and void count. As revealed by temperature profile measurements on a MID housing, it was possible to level out the heat gradients at all measurement points to a significant extent with the help of pre-vacuum, and the small temperature difference at peak temperatures which is associated with vapor phase soldering was retained as well. Furthermore, pre-vacuum can be used to assure quicker and more uniform heat-up of components with large thermal masses. In summary it can be concluded that vacuum during vapor phase soldering provides an additional, highly flexible influencing parameter for the evaluation of an ideal soldering profile and, beyond this, prevents the drag-out of Galden® in the case of cup-shaped components.

About Rehm Thermal Systems

Rehm was founded in 1990 based on the idea of building small, inexpensive reflow soldering systems with a sealed process chamber. With “Simply.More.Ideas” in the field of thermal system solutions for the electronics industry, Rehm is now a technology and innovations leader for modern, efficient electronic PCB manufacturing. As a globally active manufacturer of soldering and drying systems, we’re represented in all relevant growth markets and, as a partner to our customers, we implement manufacturing systems which are setting standards.