Vapourphase vacuum-soldering.
A new process technology opens tremendous production capabilities when reflow-soldering.

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A new machine technology combines a latest generation vapour-phase soldering machine - as optimal heat-transfer medium - with classical vacuum-technology. Thus it is now possible to solder absolutely void-free even areas as large as cigarette packages. Solder alloys with or without lead may be used with this new technology.

The problem of voids in solder joints is known since the beginning of the soldering technology. For the majority of soldering applications this was not a serious handicap, in some instances is actually considered helpful. However, with increasing integration density, the changing shape of the components as well as other demand profiles and application requirements of the electronic assemblies and their respective mechanical joints, there is an increasing demand for void-free solder joints. Until recently only small batches of such product could be processed in special vacuum ovens. There the solder product is heated either through conduction or radiation. Oxide-free soldering was only possible by applying multiple rinsings with a forming-gas. Due to the extremely long process times and a most complex process only small quantities may be soldered. Due to large process overheads and many rejects the cost for the end-product is very high.

Areas of application for void-free soldering

The main areas of application for void-free soldering increase constantly due to changing process methods and shapes of the components. Here are some examples for areas of application:

- Soldering encased power components on printed circuit boards.
- Holohedral soldering of components to heat-sinks.
- Soldering power chips to base-substrates using paste or solder foils.
- Density-soldering of high-frequency-dense throughholes.
- Soldering connections of large-surface electrical and mechanical components.
- Eliminating voids in throughholes or with connections of components (e.g. BGA‘s), to better heat-sink to cooling areas below and thus improving reliability.
- Soldering large surface SMD‘s or conventional connectors also on the most massive multi-layers.
- Repairing SMD‘s or conventional connectors in high count multilayers.

Fig. 1: Power-component on Aluminum- Oxyde.

Application of solder alloys with or without lead

According to the experience until now the void creation in conventional applications of lead-bearing solders for power components lies in most cases within acceptable limits. However, when using leadfree pastes these conditions change totally. Due to the characteristics of the solder and reduced wetting qualities there is a considerable increase in void formation. The amount of voids, e.g. in the joints of processors – which had been soldered before without problems (particularly joints with the balls of BGA‘s) may lead to insufficient heat-sinking of the component during use, resulting in the heat-death of this component. Furthermore, voids thin joint metal thickness and are always a predestined weakness in the solder-joint and may cause its failure, particularly with the reduced ductility in lead free alloys. Many companies consider void formation a problem which may be neglected. However, with great certainty the change-over to lead-free pastes will affect many companies thinking and cause them to revise their opinion as new process solutions will become necessary.

Process-description for vapour-phase-vacuum-soldering

To produce a totally void-free solder-joint and at the same time to protect the solder-product as much as possible during heating, a totally new process technology has been developed in collaboration with one of the best known

producers of power-modules. The main feature of this process is the

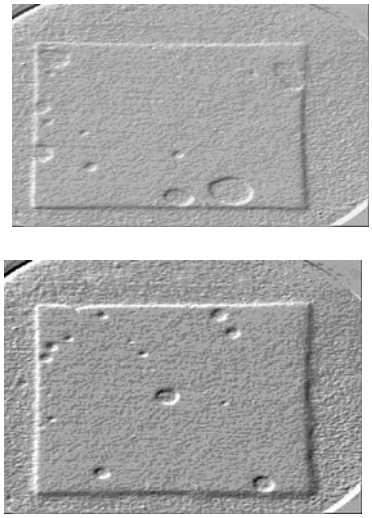

Fig. 2/3: Power-chip 12,5 CU with voids

combination of a vapour-phase soldering machine with a vaccum-chamber. The vapor phase machine of newest design pre-heats any solder-product carefully and absolutely oxide-free. The vaccum-chamber then removes any void from the still fluid molten alloy. This principle was invented 1997 by Asscon in Germany and is patented.

Through experimentation it has been determined not to be necessary to evacuate the whole unit. The vacuum-module is designed like a box within the soldering machine. The solder product, still molten, is conveyed into it after going molten. The box is tightly closed and a vaccum of approx. 40 mbar is created within this small area.

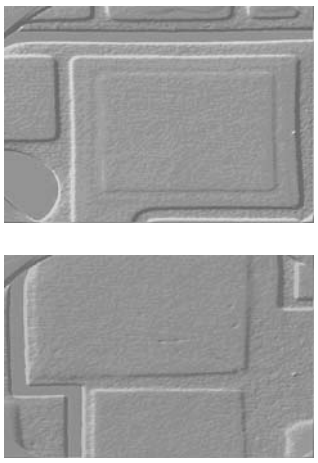

Fig. 4/5: Power-Chip 12,5 QU without void after VP vacuum-soldering

This vacuum is maintained for approx. 10 secs. During this dwell-time all voids are removed from the still molten solder. Subsequently, the vacuum-chamber will be ventilated with air or nitrogen and re-opened. Noting that the affect of oxygen in the air at this stage in the process is minimal.
Then the solder-product is conveyed into the cooling zones.

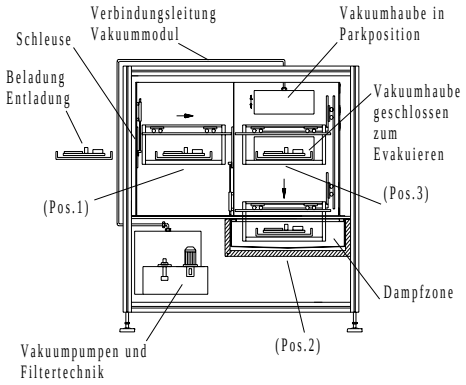

Fig. 6: General sketch of vacuum- soldering machine (Batch type)

The total process sequence is as follows:

1. Loading of the machine (Pos.1).
2. Conveying to the vapour-phase-zone
3. Preheating the solder-product with variable temperature gradients (Pos.2)
4. Conveying the still hot solder-product from the vapour-zone under a vacuum-cover (Pos.3)
5. Closing the vacuum-cover
6. Evacuate to final vacuum
7. Dwelling in final vacuum
8. Ventilate the vacuum-cover
9. Open the vacuum-cover
10. Convey to cooling-zone (Pos.1)
11. End of process.

The process is variable. The operator has to programm the following parameters.

1. Ramping during the soldering process. (linear or ramp profile)
2. Ramping of the vacuum process.
3. Hold time under vacuum.
4. Purge time
5. Evaporation time
6. Cooling time.

The process is defined only by 6 parameters. This makes it very easy, to setup a new product.

This process offers several inestimable advantages:

- The vacuum-step only extends the process-time by approx. 25 secs. compared to a normal reflow-process.
- When soldering problem-free solder-products the vacuum-module may be de-activated. Thus the machine operates as a normal reflow unit.
- Even solder-products weighing several kgs may be soldered extremely quickly.
- Lowest production overheads.
- Basic vacuum-technology as only small volumes are evacuated.
- Even with lead-free products the max. temperature is only 230° C.
- Small foot-print.
- Lowest usage cost due to optimal efficiency of the machine components.
- Mass-production series are possible with inline-systems.
- No special experience is required to operate the machine.

Process-Reliability:

The physical laws which govern the vapour-phase soldering process, combined with vacuum technology result in extremely stable process conditions. The main advantages are:

- No overheating, damage to components and/or delaminations are possible. Max. temperature for lead-free 230° Celsius.
- 100 % oxygen-free soldering.
- Extremely homogeneous energy distribution on the module. Three- dimensional products may be processed without problems.
- Lowest energy consumption due to high efficiency.
- Shortest possible process times, as due to homogeneous heating a constant gradient without dwell time may be pre-set. This offers considerable advantages particularly with sensitive components and lead-free products.
- Lowest damage potential due to lowest process temperatures and shortest possible process-times.

Prospects

The unique combination of vapour-phase with vacuum-technology will make it possible to use modern process-technologies and to process components, something that has been unthinkable using todays methods. Vapour-phase technology is ideally suited to process lead-free products, minimising the effects of Total temperature exposure and delta Ts between small devices and larger devices. Thus even complex soldering demands may be met in future – reliably and cost-effectively. The optional use of the vacuum-technology in the same machine offers producers inestimable competitive advantages. It also make it possible to go into mass-production with products which until today could only be processed in laboratories and with highly specialised machines.

Vacuum Parameters.

Vacuum drawn	20 – 40 Mbar
Time to Max vacuum	7 – 15 secs
Max time at vacuum	3 – 10 secs

The level of maximum vacuum drawn is determined by the complexity of the circuit design, in particular the number of via holes and blind vias.

Similarly the rate at which vacuum is pulled down is impacted by the design and the volume of solder material on the largest joints.

Max time at Vacuum is rarely beneficial beyond 10 secs, if a gaseous mass still exists after 10 seconds it is unlikely to work its way through to the surface.

VP 2000 In-Line system. Vacuum capable system.

VP6000 Off-line Vaccum system.

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