Blue Plasma – Vacuum Soldering with Hydrogen: Clean and Technologically Sound

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Vacuum soldering with 100 % hydrogen and plasma support to reduce oxide films on substrates, components and solder surfaces is an ideal process. Ideal in the sense that it is eco-friendly, as no fluxing agents are required, that it is suitable for all types of components and surfaces and that it has a low void rate, which is extremely important for power components.

It is necessary to remove oxide films before soldering. The reduction of oxide films on substrates, components and soldered parts with 100 % hydrogen is a safe and controllable process, especially as fluxing agents can be taken entirely out of the equation.
The thermal energy used as reactive energy for soldering with 100 % hydrogen is sufficient with soldering temperatures above 250 °C. With soldering temperatures below 250 °C, an additional amount of reactive energy is required to activate the hydrogen, which can be accomplished with plasma in an alternating electrical field.

The reduction requires the use of H^+ ions (*Fig. 1*) as specified in the following chemical equation:

$O_2 + 2H_2 \rightarrow O_2 + 4\ H^+ \rightarrow 2H_2O$

When producing power semiconductor modules, the first step is to solder silicon semiconductors with solderable rear side metallization (die) onto a DCB substrate. This procedure - called "die attach" - is used to set up the power hybrid. As highly plumbiferous soldering material is used in this process step, the soldering temperature is usually higher than 250 °C, so that efficient soldering with a hydrogen concentration of 100 % and a residual oxygen content lower than 20 ppm is possible.

Then these hybrids are soldered onto so-called heat sinks, usually at a far lower soldering temperature. Hydrogen plasma is used to ensure a sufficient oxide film reduction at this temperature rate. Through exposure to a plasma source under vacuum, hydrogen splits into H^+ ions and achieves a much higher degree of reactivity. This ensures a high-quality soldered joint between the parts to be bonded (*Fig. 2*).

So in both cases, the applied process using 100 % hydrogen without fluxing agent creates a high-quality soldered joint. Even under real production conditions, the vacuum soldering systems of the *VLO* series made by *centrotherm* offer extremely good wetting as well as a void rate far below 2 % (*Fig. 4*) due to the reduced oxide film.

A low void rate allows for an efficient thermal transfer from the die into the substrate and from there to the heat sink, making high performance rates possible. The manufactured power modules find buyers in many high-profile branches of industry such as train, automotive and automation technology. The high degree of efficiency of these electronic power components greatly reduces the use of electrical energy.

For more than 30 years, *centrotherm thermal solutions* has designed, produced and sold high-end equipment as well as components for thermal semiconductor and photovoltaic processes. The range of products includes horizontal and vertical furnaces, conveyor furnaces, vacuum soldering ovens as well as process technology services. *centrotherm* has many years of experience in designing and manufacturing *VLO* series equipment in combination with H_2 technology. These

systems have been deployed all over the world and contribute to energy conservation efforts on a daily basis. The use of hydrogen technology requires extensive safety measures and expert handling of hardware and software, an expertise which centrotherm gladly shares with its customers.

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Figures and Captions

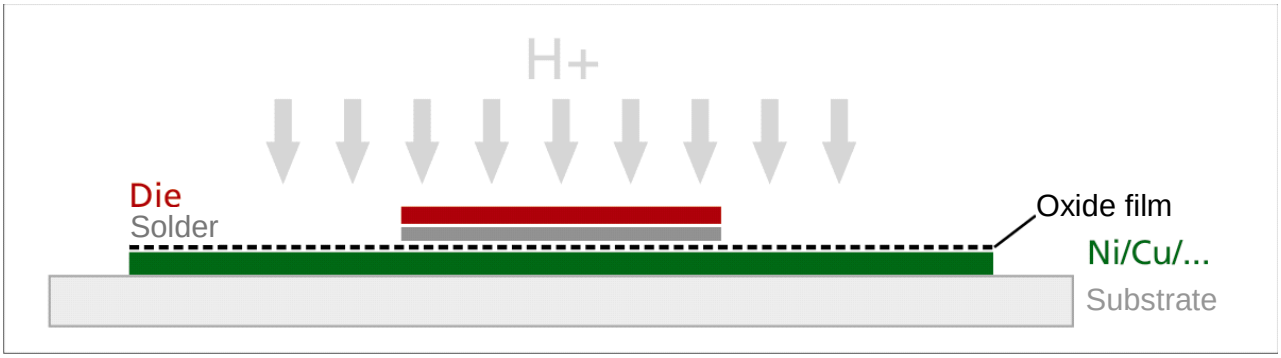

Fig. 1: Schematic Configuration of a Hybrid Stack

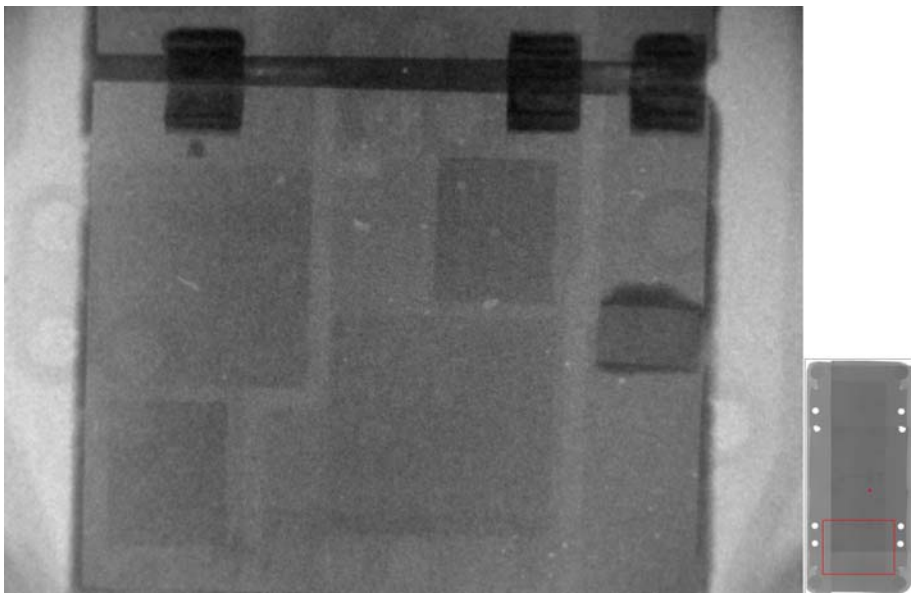

Fig. 2: Power Semiconductor soldered on Heat Sink (excellent soldered joint)

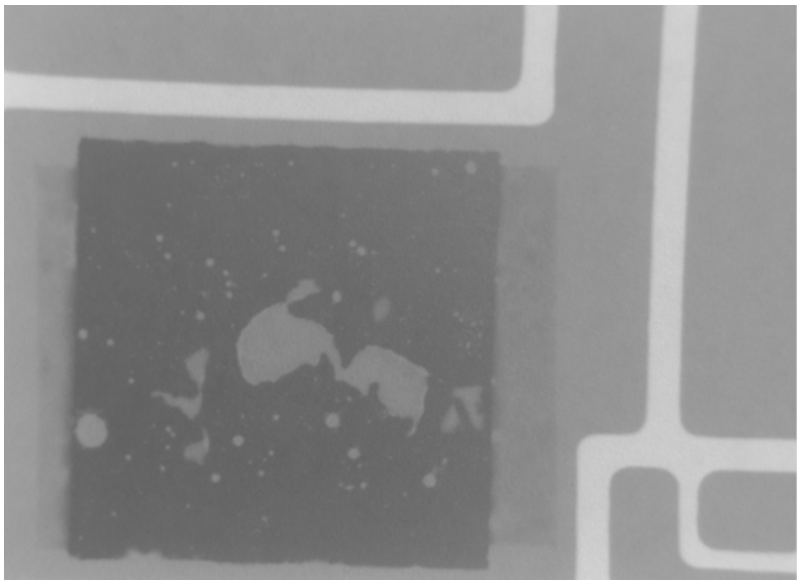

Fig. 3: Soldered Joint under Die with Void Rate of 10,8 % of Surface (poor quality)

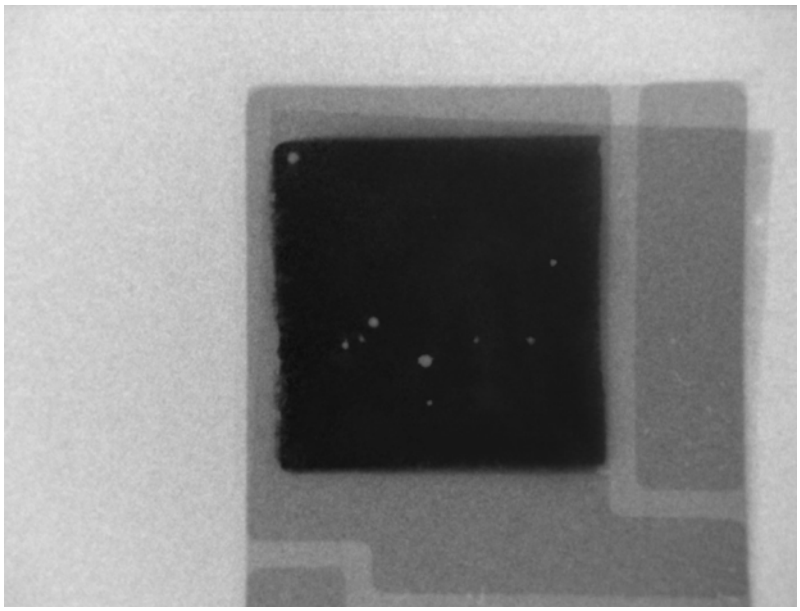

Fig. 4: Soldered Joint under Die with Void Rate of 0.6 % of Surface (excellent quality)