

Blue Plasma goes Green.

Water as Effective Alternative for Fluxing Agents.

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1. Introduction

In the era of green production in electronic engineering, centrotherm thermal solutions is looking for ways to take advantage of the reducing effects of hydrogen (Figure 1) for oxide layers by merging the knowledge available in the fields of photovoltaics, frontend and backend solutions.

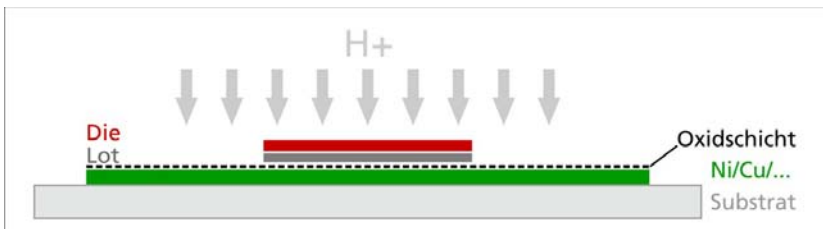
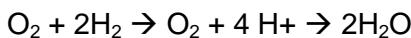


Figure 1: Hydrogen as Reducing Process Gas



Differing safety concepts in different facilities make it almost impossible to make full use of H₂ as reducing process gas.

Nonetheless, centrotherm thermal solutions has developed Blue Plasma with deionized water as process gas alternative to utilize the advantages of hydrogen in industrial soldering process solutions.

Deionized water is available worldwide, can be stored very easily and has practically no ecological footprint.

2. Process Description

a.) Low Pressure Plasma

Plasma is matter's fourth state of aggregation. Matter changes its state of aggregation as energy is supplied. So if energy is continuously supplied to solid matter, it will change from

solid to liquid to gas. Upholding the energy supply will break the electron shells within the gas to generate negatively charged electrons, positively charged ions and smaller complete molecules. For example; applying high-frequency electrical fields to pure gas or a gas mixture in a vacuum chamber will generate a low pressure plasma. The gas/gas mixture is ionized and radicals (negatively charged electrons and positively charged ions) are generated. The partial recombination of electrons and ions will create visible UV radiation (in this case, a deep-blue coloring caused by H₂ component). With suitable parameters for mixture composition, coupled energy, gas flow and excitation frequency, the excited gas/gas mixture can be used for systematic surface modification.

b.) Deionized water as plasma gas mixture

Heating deionized water will change its state from liquid to gaseous (water steam). Pressure (energy supply) is then used to inject the gas mixture into the vacuum chamber in very small quantities. If, in addition, an alternating electrical field is applied, H₂O plasma will be generated as specified in the following simplified formula:

- Reaction steps in the alternating electrical field (energy supply)
- 1st step: $4 \text{ H}_2\text{O} \rightarrow 2\text{H}_2 + 4\text{OH}^-$
- 2nd step: $2\text{H}_2 + 4\text{OH}^- \rightarrow 4\text{H}^+ + \text{O}_2 + 2\text{H}_2\text{O}$
- 3rd step: $\text{O}_2 + \text{C} \rightarrow \text{CO}_2$ (ashing of the carbon layer by O₂)
Note:: Carbon layer from environmental condition, commonly known as „contamination“
- 4th step: $4\text{H}^+ + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$ (reduction of the oxide film by H⁺ ions)

3. Advantages of the Process

- no expensive safety engineering
- deionized water is cost-efficient and available worldwide
- deionized water is easy to store and has practically no ecological footprint
- can be combined with all centrotherm plasma processes
- fluxing agents can be taken entirely out of the equation by the process mentioned above
- great reducing effects with regard to oxidized surfaces
- additional fine cleaning effects with regard to carbon layers

4. Technical Implementation by centrotherm thermal solutions

Normally, humidity is exactly the kind of thing you do not want in a vacuum chamber.

So there are some technical issues that need to be looked into if we plan on using water as a process gas which we are going to split into radicals (electrons and ions) in an electrical field.

centrotherm thermal solutions has found a way of injecting very small quantities (mg/h) of water, which is converted into water steam, into a vacuum chamber.

To make this happen, centrotherm worked with ideas which were originally developed in the automotive branch. By combining these ideas with the latest developments in micro-dosing

technology, centrotherm was able to develop and bring to market a solution which meets industrial demands. See figure 2: H₂O injection with a plasma generator.

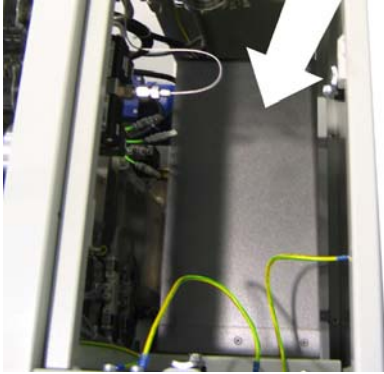


Figure 2: H₂O Injection with a Plasma Generator

5. Summary

The implementation of an industrial process with uses deionized water as an alternative to fluxing agents can be rated as a success.

Soldering tests with H₂O plasma on strongly oxidized hybrid carriers showed very promising results. centrotherm's VLO 20 can be used to run a controlled, stable and reproducible H₂O plasma soldering process which meets industrial standards. See figure 3



Figure 3: SnPb Soldering on Copper with centrotherm H₂O Plasma



Figure 4: SnPb Soldering on Copper without centrotherm H₂O Plasma

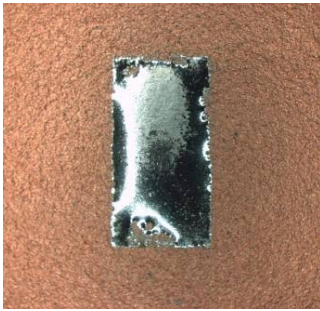


Figure 5: SAC Soldering on Copper with centrotherm H₂O Plasma




Figure 6: SAC Soldering on Copper without centrotherm H₂O Plasma

6. Prospects

With frontend, photovoltaic and backend solutions, centrotherm can draw from a wide range of products which make it possible to quickly develop vacuum soldering system solutions for the industrial market. centrotherm offers proven vacuum soldering solutions which meet industrial standards thanks to the modular VLO line concept which covers various process requirements (highly plumbiferous, SAC solders, glass solders, hard solders) at a temperature range of up to 650 °C. centrotherm's new high vacuum (10^{-5} mbar) and heating concepts can be combined with various conventional activation agents such as forming gas (N₂/H₂ 95/5 %), formic acid (HCOOH), hydrogen (H₂ up to 100 %) and/or plasma activation agents (RF and/or MW) for fast heating ramps (JEDEC/IPC compliant) and fast cooling ramps (3 K/sec) .

As a result, centrotherm solutions are not only used for power semiconductor vacuum soldering but also for other industrial applications such as advanced packaging, optoelectronics and MEMS/MOEMS.

Our VLO development team and the soldering laboratory have combined forces to optimize tried and approved solutions and to develop new fields of application.

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Since 2006, Ulrich Völler has been product manager for the Vacuum Soldering Systems at centrotherm thermal solutions GmbH + Co. KG.

Mr. Völler graduated at the Technical University of Esslingen, then spent many years working for the TZM Technology Center for Microelectronics as a team leader for Packaging, Manufacturing and Development Services.

About centrotherm thermal solutions:

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.