Reactive joining with braze: Novel zirconium based systems

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Reactive multilayer systems (RMS) consist of at least two materials made of hundreds of alternating, nanometer-thick individual layers with a total thickness of several micrometers. When they are activated, an exothermic, self-propagating reaction occurs. The heat released in this process is used to bond components of both the same and different material classes. RMS can be used as an integrated coating or as a free-standing film.

Customized joining for a variety of applications

RMS technology is particularly appealing in terms of its precision and adaptability. The heat of reaction is released in a few milliseconds, so that the heat influence on the components is kept to a minimum. Applications to date include the joining of e.g.

- temperature-sensitive electronics,
- hermetically sealed components,
- materials of different material classes and
- strongly varying thermal expansion.

New possibilities with new material systems

Excellent results are achieved with the RMS made of nickel and aluminium with soft solder or when used with thermoplastics, which have been established on the market to date. Nevertheless, the possibilities of this type of RMS are limited. With novel, higher-energy material systems, temperatures can be reached that allow the RMS technology to join with hard solder. The resulting joints are stronger (Fig.1) and withstand higher thermal loads due to the higher brazing melting point (Tab.2).

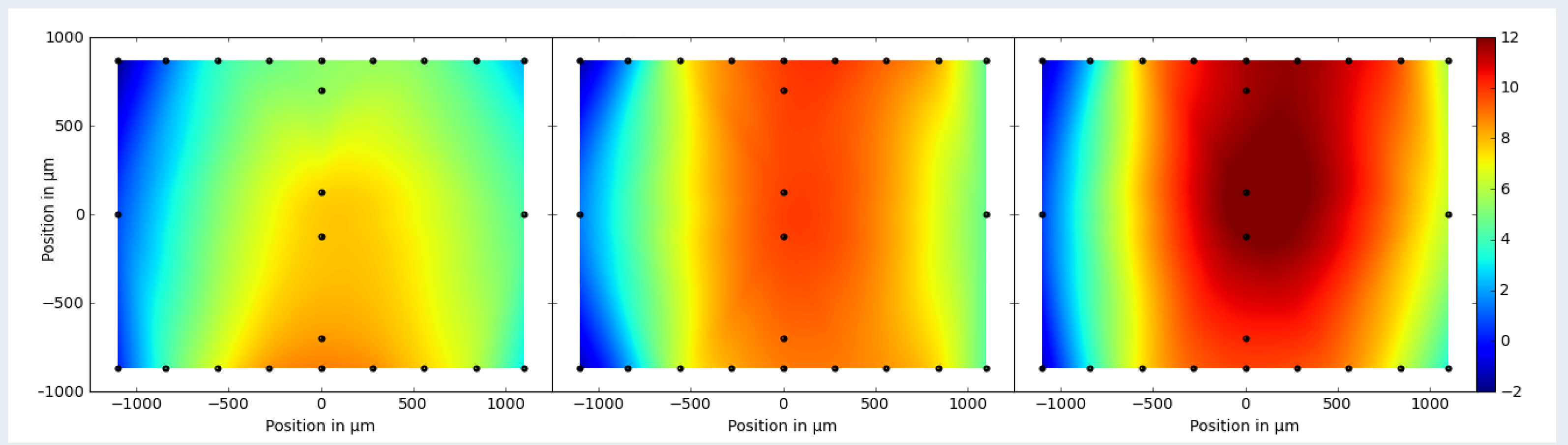

Fig.1: Stress distribution over surface of a CMOS stress sensor, interpolation of signals from 24 strain sensors (black dots), at an applied tensile load of 1200N. Left: reflow soldered (SAC), middle: with Ni/Al film + soft solder (Sn), right: Zr/Si/Al coating + braze (AlSi12) [1]
The better sensitivity of the braze-joined sensors indicates the stronger bonding.

Development of Zirconium RMS

The newer zirconium-based material systems researched at the IWS additionally contain silicon and aluminum. The ternary Zr/Si/Al RMS offers advantages such as a broader field of application, as well as easier fabrication and handling due to less hazardous materials. Although the energy released is enormous (Tab.1), the reaction remains very localized and there is no thermal influence on the components. Joining with brazing alloys could thus be realized.

Comparison of different RMS types (Si-quartz joint) [2] [3]

RMS type	Adiabatic reaction temperature
Ni/Al	1639 °C
Zr/Si	2250 °C
Zr/Si/Al 14 µm „high-energy"	900 °C real boundary temp.
Zr/Si/Al 14 µm „highest-energy"	1200 °C real boundary temp.

Comparison of different solders and brazes

Solder type	melting point ca.
Tin/lead solder (soft solder)	180 °C
SAC-solders (soft solder)	230 °C
AlSi12 (braze)	580 °C
InCuSil™ ABA (braze)	715 °C

Target bonding with RMS

Bonding of sputtering targets with Ni/Al-RMS is an already well-established process in the industry. In a matter of seconds, metallic or ceramic sputtering materials are reactively bonded to back plates, which are usually made of copper. Tin-based soft solders, which have a melting point below 230 °C, are often used for this purpose. However, the process of sputtering can apply several kilowatts of power to the target, resulting in high thermal stress. Brazing alloys are better able to withstand this stress, which is why development is being driven in this direction.

Fig.2: Ceramic sputtering target reactively bonded to a copper back plate (left), Stress sensor joined with Zr/Si/Al-RMS (right, cf. Fig.1)

Reactive joining brings the required heat into the joining zone locally and in a very well-dosed manner. The resulting flexibility of the process is particularly suitable for customized processes such as target bonding with its various material pairings. The next RMS generation now opens up the field of reactive brazing, thus expanding the range of applications for RMS technology.

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