Fraunhofer IWS

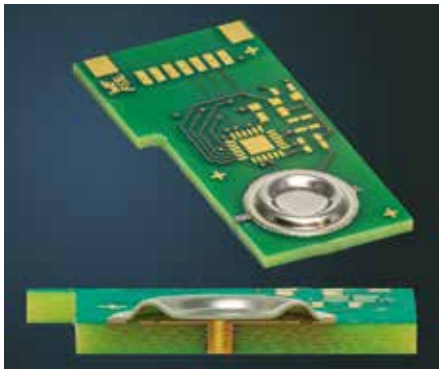
Reactive Multilayer Systems

Gentle and Tailored Joining of Different Material Classes

Top
Reactive bonding of an optically coated silicon mirror to metal foam structures for use as a laser scanning mirror.

Bottom
Hermetically sealed reactive bonding of chips and sensors.

Reactive multilayer systems (RMS) provide a precisely definable amount of heat within a few milliseconds for the gentle joining of components. They consist of several hundred periodically built-up layers from two materials with individual layer thicknesses of a few nanometers. Heat is released through an exothermic reaction and can be used for reactive joining of components. Due to their unique properties, RMS facilitate the bonding of, for example, temperature-sensitive components, hybrid joints and materials with different coefficients of thermal expansion. In doing so, the joints exhibit sound electrical and thermal conductivities as well as high strengths. Fraunhofer IWS Dresden develops such RMS and analyzes their potential in different fields of application.



Structure and principle of RMS

Fraunhofer IWS has developed inner joining zone heat sources with reactive multilayer systems. RMS consist of at least two materials, built up from alternating single layers of less nanometer thickness, reacting exothermically in a self-propagating manner after exposure to an activation energy. The resulting reaction heat is used to melt the base material or solders to produce compounds within a few seconds. Due to the short reaction time and the adjustable amount of heat released and used in reactive joining, the components adjacent to the joining zone show minimal thermal stress. RMS can be deposited directly onto components or used as mobile, free-standing films.

Fabrication and properties

In recent years, Fraunhofer IWS has developed suitable material systems for RMS with a wide range of properties. The RMS are fabricated by the vacuum deposition process magnetron sputter deposition. In addition to the material system selection, the stoichiometric ratio of

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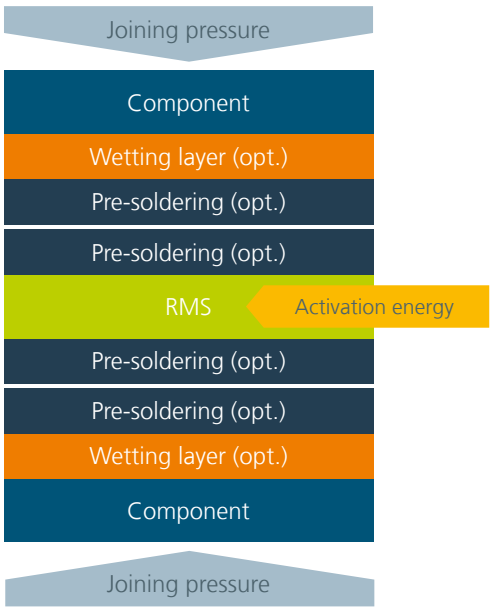
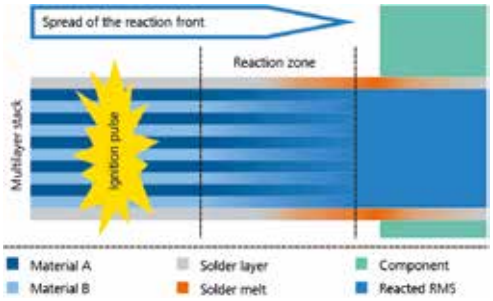
Parameters for RMS Use

RMS materials	Ni/Al, Ti/Al, Zr/Si, Zr/Al
Total RMS thicknesses	5–100 µm
Maximum reaction temperatures	600–2300 °C
Reaction velocity	2–30 m s^{-1}
Required joining pressures	0.1–30 MPa
Joining time	< 1s
Activation energy	Electrical spark, laser pulse, heat

Joining Process Using RMS



Principle of an RMS Reaction



Initial state with reaction initiation. Diffusion process by chemical reaction (center), release of reaction heat to join components.

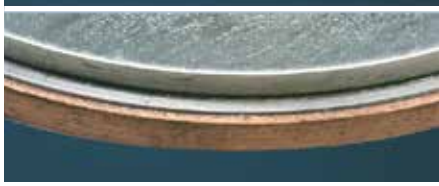
the reaction partners can also determine the RMS properties enthalpy and reaction front velocity. This allows low-melting materials, plastic materials for instance, as well as metals or ceramics to be joined via solders. The required joining pressure also exerts a significant influence on the joining properties, such as strength or tightness. If, for example, precise joining surface designs are required in microsystem technology and housing construction, the RMS can be structured by laser in the case of films or by shadow masks in the case of direct coating.

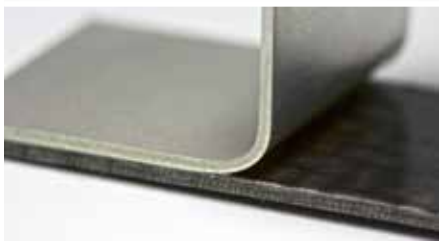
Fields of application

- Microsystems technology
- Scanner systems/mirrors
- Sputtering targets for vacuum coating
- Lightweight construction
- Automotive

Advantages

- Tailor-made, gentle joining process
- No change in component properties
- Joining of different material classes
- Short joining process times (< 1 s)
- Long-lasting, strong and tight joints





Top
Hermetic and solid reactive bonding of a car door rubber seal.

Center
Target bonding using RMS for coating processes in vacuum.

Bottom
Reactive bonding of a hat profile of hybrid metal-plastic joints.