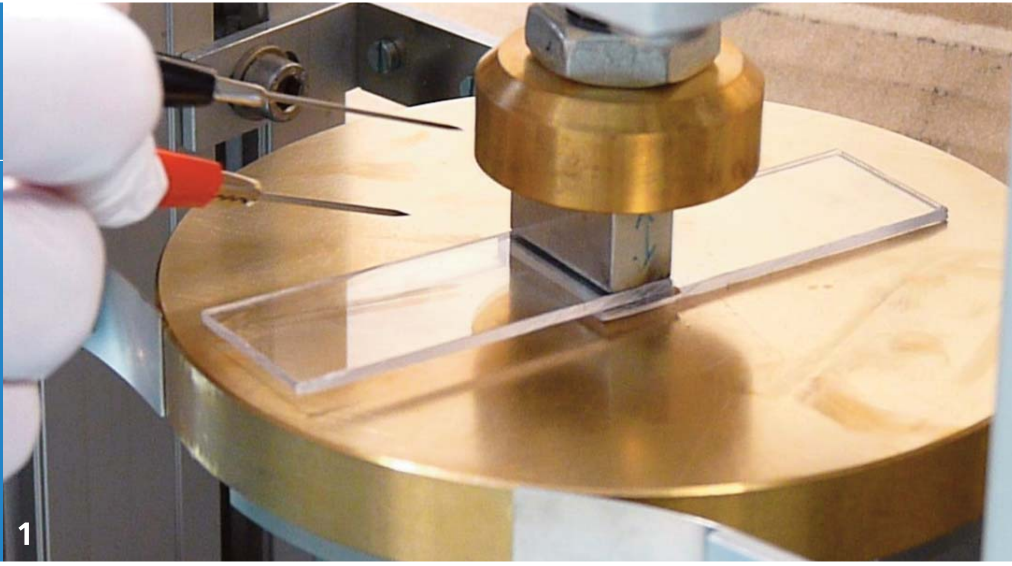

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NANOMETER REACTIVE MULTILAYER COATINGS FOR PRECISE JOINTING PROCESSES WITH LOW TEMPERATURE IMPACT

THE TASK

A frequently reoccurring task is to solidly join two different parts. Ideally one just has to hold the two parts together and press a button to immediately form a solid joint. The reality is different. Adhesive bonding processes require curing the adhesive. Soldering and welding require heating the parts to be joined. New joining processes can overcome these limitations and they are of particular importance for the following applications:

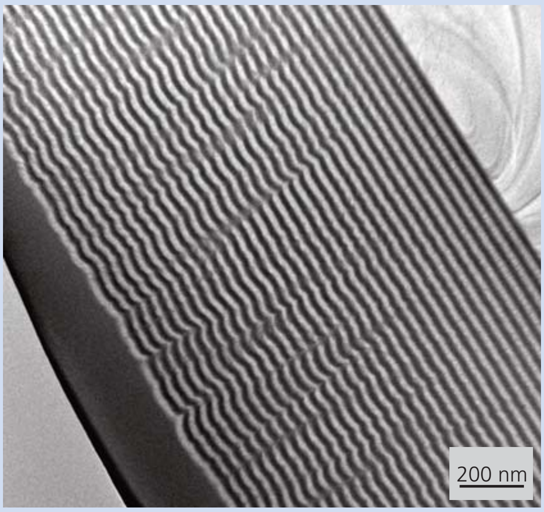
- low heat impact precision joining of micro system components
- joining of parts made from very different materials (e.g. ceramics and metals)
- short and precise heat impact to join polymers

OUR SOLUTION

Fraunhofer IWS engineers use a new approach, which could make the ideal joining process vision a reality. A reactive multilayer coating is placed between the surfaces to be joined. An electrical pulse activates the multilayer and within milliseconds the parts are connected without overheating (Fig. 1).

The principle is based on an effect observed on specially designed nanolayer film structures. Initially the foil consists of many individual layers made from at least two different materials (Fig. 2). The activation of atomic diffusion in such multilayers causes chemical reactions to initiate. These exothermic reactions then briefly release heat in a very localized region defined by the foil location. This heat is used to melt a solder placed on both sides of the multilayer. It can also melt the surfaces of the parts to be joined. When solder or surfaces are solidified the parts are joined. There is almost no limitation with respect to the parts. Metals, ceramics, semiconductors, diamond and most recently even polymers can be effectively joined.

TEM image of a cross section through a nanometer reactive multilayer (Picture: Dr. Rümmeli, IFW Dresden)



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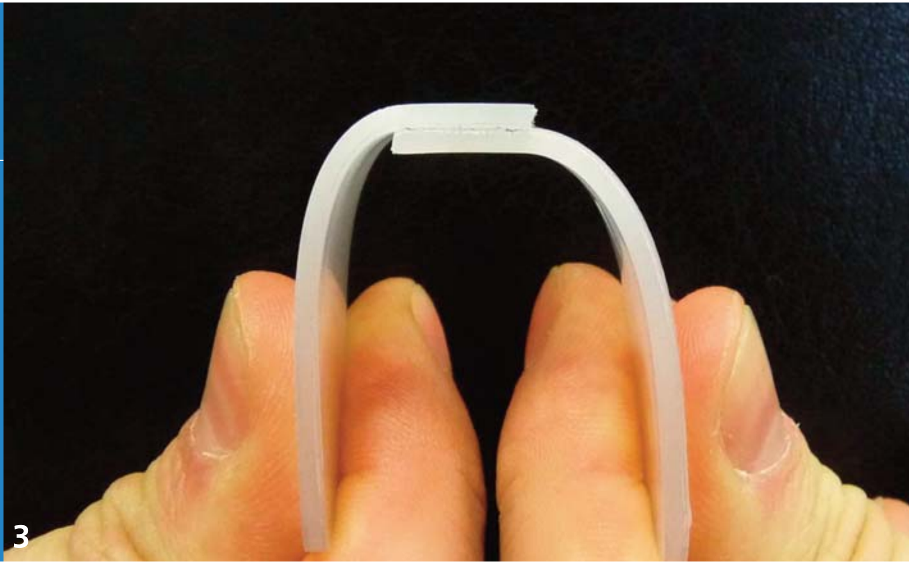

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RESULTS

Recently the basic technique was further developed to also include solders with higher melting points. The previously exclusively used soft solders melted at 200 - 300 °C. The process can use hard solders that melt above 700 °C. Parts joined with such solders can be used at high temperature loads.

Such solders also improve the strength of the joints. The application of these solders was made possible by doubling the energy amount store in reactive multilayer coatings. This work is being continued with the goal to enable solders with melting temperatures exceeding 1000 °C. This is a very interesting temperature region for joining ceramic materials.

A second very important aspect of recent work is the joining of polymers (plastics). Within a short time we were able to achieve very interesting results. Polymers can be joined without the use of solders. The foil provides energy to directly melt the surfaces of the polymer parts. Thus the polymer parts are directly welded.

Especially advantageous in this case is that the energy amount to be delivered by the foil is precisely adjusted via the design of the nanolayers. The precise energy delivery avoids burning of the polymers and established a well-defined liquid phase. The mentioned examples and developments show that tailored reactive foils can make "joining upon pressing a button" a reality.

1 Joining of polymers with RMS

3 Strength test of polymer parts, which were joined by reactive multilayers

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