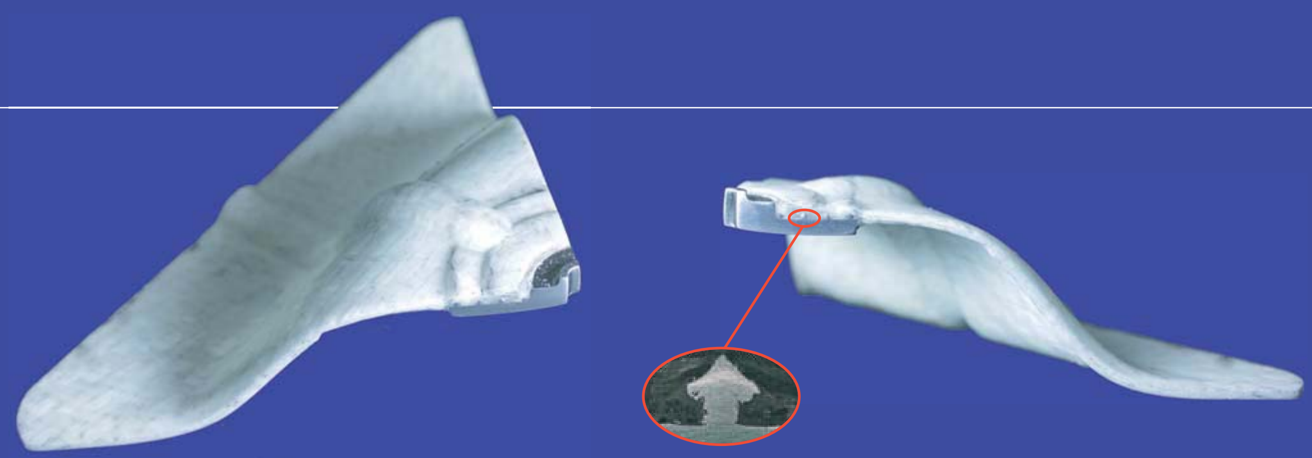


1

THERMAL DIRECT JOINING OF METAL AND THERMOPLASTICS

THE TASK

Tailored mixed material joints which combine the specific advantages of metals and thermoplastics are becoming more important for industrial applications and in particular for lightweight construction. Efficient process chains are required which employ optimized pre-processing and joining technologies, tools and simulations as well as material characterization. The resulting joint properties need to be tailored for specific application environments.

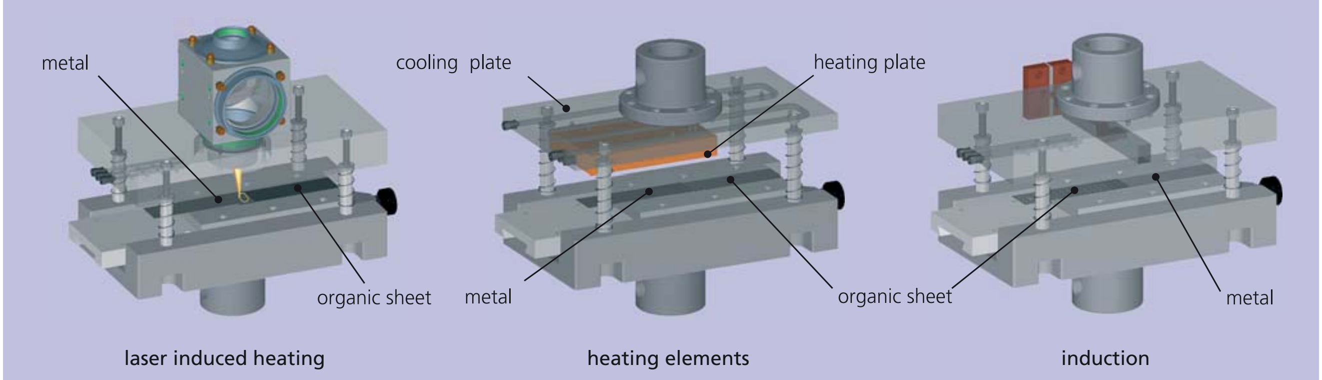
Typical processes to join dissimilar materials are post and inmold assembly, mechanical joining techniques such as bolting, riveting and adhesive bonding. Specific restrictions of these processes result in particular due to:

- limited complexity of shapes,
- locally reduced cross sectional areas with disturbed flow of forces in fiber reinforced plastic composites,
- the necessity to introduce additives and
- increased process times.

OUR SOLUTION

Fraunhofer IWS engineers have substantial materials and process know-how addressing laser and plasma based manufacturing technologies. This capability is applied to develop surface pre-processing and adhesive bonding technologies as well as to study thermally induced joining techniques. Direct thermal joining processes are fast and eliminate the need for additives (e. g. adhesives). To join metals and thermoplastics, IWS engineers apply suitable surface structuring, adhesion promoting layers and different heating concepts. Heat is applied using laser radiation, heating elements or induction (Fig. 2). Another method to deliver a short burst of heat is the use of reactive multilayer coatings (RMS).

Schematics for different heating concepts



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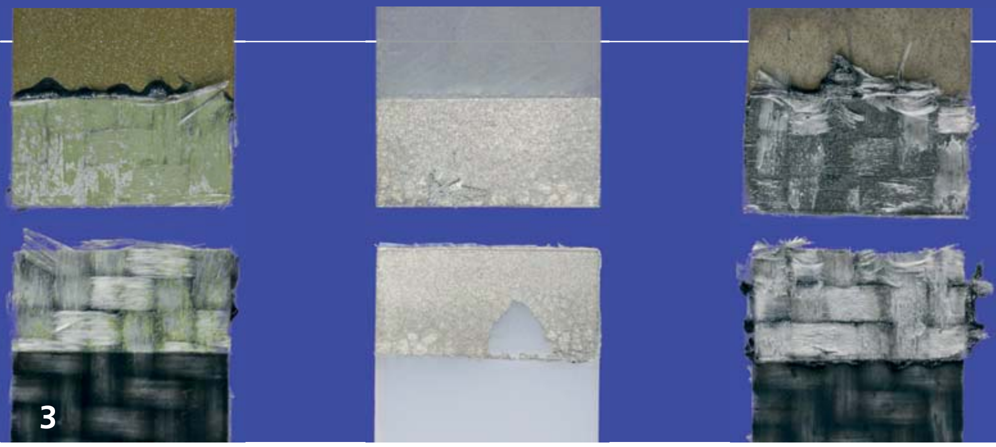
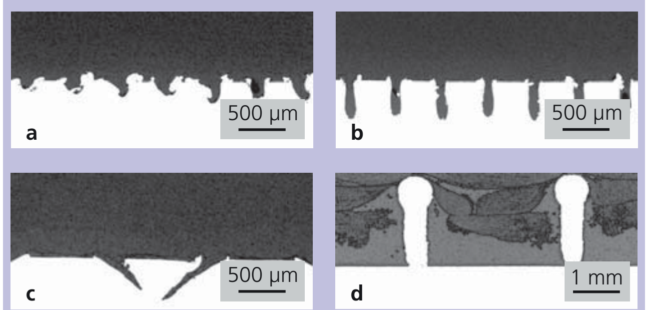


3

RESULTS

The first step is to structure the metal surface (Fig. 4a-c) or to generatively add structures (Fig. 4d). The particular pattern of the surface structure aims at providing the best adhesion for the melted thermoplastic material for a given application. This way the connection between plastics and metal relies on form fitting and non-covalent forces (Van-der-Waals). The strength of thermoplastics-metal joints can be further increased by using adhesion promoting layers, which are selected depending on the materials used. These direct joints combine the effective principles of form fitting and adhesive bonding technologies.

Direct joints with adapted surface structures to improve the joint strength of metal (below) and thermoplastics (a-c) and to fiber reinforced composites (d)



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Engineers of the Fraunhofer IWS in Dresden are studying different heating methods to join thermoplastics and metals of complex geometries. The goal was to identify cost-effective methods and to explore application potentials and limitations of the techniques. Compared to conventional heater elements, laser induced heating has the advantages that the heat can be locally deposited and that the process is suitable to work with more complex part geometries. It is also possible to apply a temperature gradient by integrating pyrometer control.

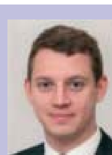
Heating inductively requires well developed knowledge about the geometry of the joining zone, the material behavior as well as the processing approach in order to dimension the inductor and the generator. This method has the advantages of being very fast and its capability to deliver heat to regions that are optically inaccessible. This is similar for using RMS foils. If the process is designed just right, the heat deposits directly at the contact interface between metal and thermoplastics.

All the described methods rely on heat convection in the contact interface to plasticize the thermoplastic material or the thermoplastic material matrix of pre-consolidated fiber reinforced composites (so-called organic sheets). Under pressure the plasticized material flows into the fabricated structures, which have undercut geometries. There the material solidifies to connect in a form fitting way with the structure or to bond with the adhesion promoter. The process can be as brief as a few seconds. The short processing time is a decisive advantage compared to conventional processes such as adhesive bonding.

1 Glass fiber polypropylene suspension strut dome with directly connected stainless steel dome bearing

3 Fracture surface of metal-thermoplastics joints

CONTACT



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