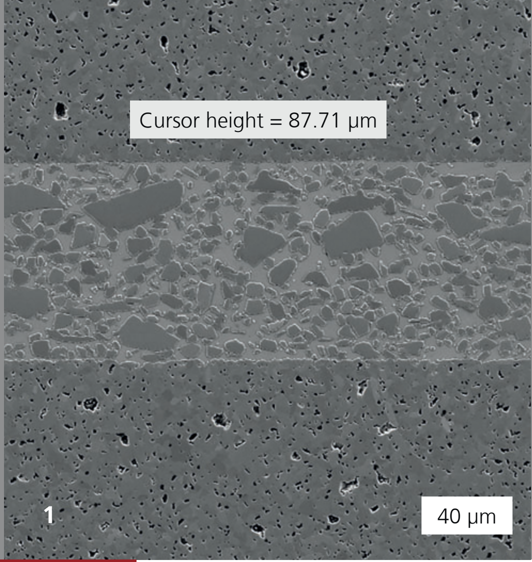

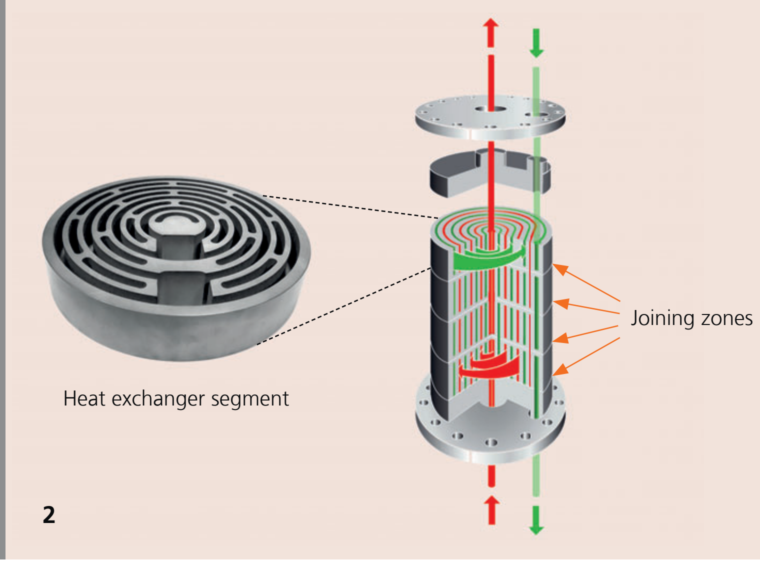

ENERGY

GAS-TIGHT JOINING OF CERAMIC HEAT EXCHANGERS MADE OF SILICON CARBIDE

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For the waste heat recovery from chemical reactions, modular recuperators made of sintered silicon carbide have become established in many industrial applications. However, the sealing and joining technologies of individual commercially available recuperator segments put restrictions on the chemical and thermal load capacity of heat transfer systems. To overcome these technological limitations, Fraunhofer IKTS and its industrial partner GAB Neumann GmbH have developed a process for the cohesive ceramic bonding of silicon carbide ceramics.

The joining process begins with a tape made of polymer-bound silicon carbide particles. By using a cutting laser, the tape can be tailored precisely to the dimensions of the component surfaces to be connected. This also enables the production of complex cutting patterns. The component surfaces to be connected can then be joined with the cut tape even at low temperatures of approx. 200 °C. Since thermoplastic binder is used, this can be done cost-efficiently, with only a minor effort in terms of instruments, under air and at low pressures starting at about 1 MPa. The tape can be draped easily and, in its plastic state, is able to optimally level out uneven areas. Therefore, it is also possible to join spherical or rough surfaces.

Subsequently, the thermoplastically connected parts are subjected to pyrolysis. During this working stage, the plastic binder in the joint transforms into glassy carbon. The resulting porous carbon zone, which contains silicon carbide, can be converted into a dense silicon-infiltrated silicon carbide (SiSiC) joining layer during a high-temperature step at about 1600 °C. For this purpose, silicon powder must be stored in reservoirs with direct contact to the joining zones. The reservoirs may be introduced in the form of grooves or blind holes in the material. When the melting temperature (1414 °C) is exceeded during the heat treatment, the silicon liquefies in the reservoirs and is drawn into the joining layer by the capillary forces, where it reacts with the present free glassy carbon to form secondary silicon carbide. The result is a gas-tight joint of silicon carbide with silicon-filled cavities.

The resulting ceramic joining layer is approximately 80–120 microns thick. It is suitable for high temperatures and very resistant to chemicals. The industrial partner GAB Neumann GmbH currently uses this newly developed joining technology for the first time in plate and annular groove heat exchangers.

Services offered

- Development of ceramic joining processes
- Application-related materials development
- Development of manufacturing processes for the industrial fabrication of complex ceramic components
- Recuperator design optimization using CFD simulations
- Development and optimization of adapted heat treatment processes

GAB neumann
Bundesministerium für Wirtschaft und Energie
ZIM Zentrales Innovationsprogramm Mittelstand

1 *Joining zone between two SSiC parts.*

2 *Annular groove heat exchanger segment to be joined.*

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