



- 1 Array with special antenna for direct heating of carbon-fiber-reinforced composites.
- 2 Array positioned over sample.

## PROCESSING CARBON-FIBER-REINFORCED COMPOSITES WITH MICROWAVES

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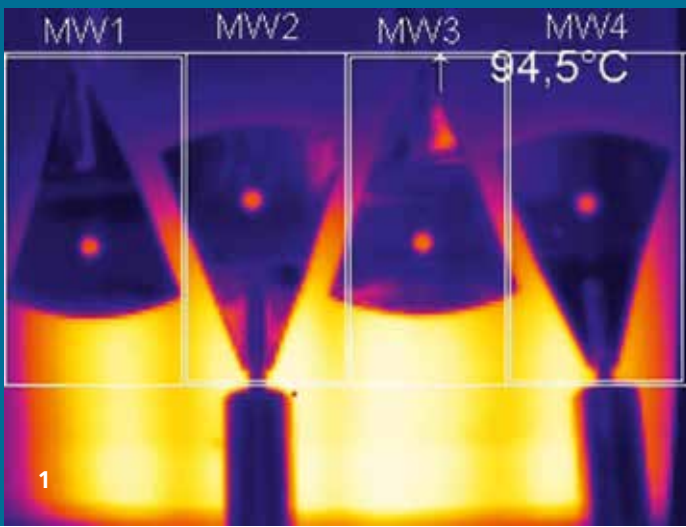
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Most composite processing is carried out under heating. Conventionally this occurs through contact heating or infrared radiation. These techniques heat the surface of the material and the warmth is transferred to the interior until the material has been heated thoroughly. Due to the low thermal conductivity of composites, this process is time-consuming and energy-inefficient. The maximum surface temperature is also limited because of degradation and other undesirable changes in the materials.

Due to their long wavelength, microwaves have a considerable penetration in many polymers. It is therefore possible to transfer heat deep inside the material without contact. Heating occurs volumetrically and is nearly independent of thermal conduction properties.

### Direct heating of carbon-fiber-reinforced composites

Carbon-fiber-reinforced composites produce a shielding effect which reflects most of the microwave radiation, inhibiting rapid and energy-efficient heating. Researchers at the Fraunhofer ICT have developed and patented a special microwave antenna with which this shielding effect can be overcome. It was possible to combine various individual microwave antennae to form an antenna array. This array can be mounted on a robot or gantry crane and moved over the sample during heating. In addition the antenna system can be integrated into a mold. Each antenna is equipped with an IR-sensor to measure the temperature and to control the microwave power.



### Application

The antenna and the corresponding array have numerous potential applications covering the whole field of the processing of carbon-fiber-reinforced composites. For example:

- Curing of *c/f*-reinforced composites (matrix thermoset)
- Consolidation *c/f*-reinforced composites (matrix thermoplastic)
- Heating of *c/f*-reinforced tapes
- Welding of thermoplastic *c/f*-composites
- Heating technique for preforming

### We offer:

- Consultancy and concept design
- Feasibility studies
- Numerical simulation of electric field and heat flow
- Programming of measurement and control technology
- Process development
- Thermography
- Construction of demonstrators
- Test runs and validation

### Conclusion

A microwave antenna and an array were developed for the direct heating of carbon-fiber-reinforced composites. With the direct heating the processing time of carbon-fiber-reinforced composites can be reduced significantly in specific applications from several hours to less than one hour. The temperature control ensures the homogenous and reproducible processing of the composite.

1 *IR-view of the direct heating of *c/f*-reinforced composites with microwaves.*