

**Microwave Innovation for Industrial Composite Fabrication  
– The HEPHAISTOS Technology**

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A novel automated 2.45 GHz microwave processing system HEPHAISTOS (High Electromagnetic Power Heating Autoclave InSeT Oven System) for small and medium sized structural parts of CFRP (carbon fibre reinforced plastics) has been developed at IHM. The current system integrates advantageously the basic processing steps as tooling, tempering of the resin, the impregnation of the fibres as well as finally the curing of the laminate. The main hardware contribution of the development is realized for a specific modular applicator containment providing an excellent homogeneous electromagnetic field distribution, which is applied as an upgrade tool for conventional autoclave systems. The fabrication process can be performed pressurized or at standard conditions. The process is measured remotely by sensors and can be fully automatized.

Homogeneous field distributions for high performance materials processing are essential for commercialized industrial systems. Monomode applicators involve only controllable field properties in small specific applicator regions, whereas multimode ovens promise, especially for frequencies higher than 2.45 GHz the possibility for low field fluctuations in larger regions. Simulations and experiments have shown, that achieving high quality homogeneous field distributions over most of an applicator volume is not trivial, even at frequencies in the millimetre-wave regime (30 GHz). The HEPHAISTOS concept combines basically new proven theoretical field prediction technologies successfully applied at first for millimetre-wave research systems [1] as well as an adaptive electrothermal software driven process control for a precise monitoring of the current heating state of a single CFRP work piece.

The fabricated composite materials have a broad application range within the aerospace and transportation industry. The most commonly used advanced composite fibres are carbon and graphite, Kevlar and boron. However, the full potential in the design, the manufacturing process and the application of these materials has conventionally not been realized. A specific bottleneck for wide spread application is the price/kg in comparison to aluminium, which is not yet competitive due to high fabrication costs (material costs just about 30% of the actual end price). The HEPHAISTOS technology implies a high potential on cost reduction for the full industrial manufacturing process.

[1] Feher et al.: The MiRa/THESIS-Code package for resonator design and modelling of millimeter-wave material processing, 1996 Spring Meeting of the Materials Research Society, Microwave Processing of Materials V, San Francisco, 1996, Symposium Proc., Vol. 430, pp. 363-368

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