Emerging Applications for Microwave Technology in Chemistry, Polymers and Waste

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Applications and Discussion

It is obvious that as the microwave generation and transmission get more affordable, the number of its applications is increasing. The straightforward example for the integration of microwave is the food industry (Fig. 1). Besides the general household oven consuming microwave, the technology has found use for other applications in the food industry. The possibility of electronic re-arrangement of the power in microwave technology, thus supplying a different range of temperatures in the defined space enables microwave to be used in different fields of food industry such as (re)heating, baking, tempering, dehydration, pasteurization and even popping.

In contrast to classical variants of applications, there is a constant demand for new dietary varieties in the modern food industry that can be implemented quickly and efficiently by means of microwave energy. Amongst these one may mention the popping up of cereals and cheese products, the preparation of dried meat chips, as well as the preservation of fish and meat products by microwave assisted brine injections.

Furthermore, heating ability soon was utilized in production fields, namely rope, rubber and wood. In contrast with conventional ovens, microwave resonators can be adapted to increase the efficiency in the production line.

The latest production facilities with a microwave heating are so called conti-presses, with microwave warming integrated into the pressing area, for the production of lightweight building boards for doors and cupboard systems or even robot-guided microwave generators for the selective drying of moisture nests in multilayer sanitary ceramic parts (Fig. 2).

It is only logical that this claim has spread beyond and is further adapted to bio and pharmaceutical industry. In these industry sectors, the microwave technology is predominantly used for drying and disinfection applications in batch processes. The possibility for sterilization with microwave technology by proper refinement has created a large market as an alternative technology in latter fields.

Figure 1: Microwave fruit dryer

Microwave technology, which is still sometimes not preferred because of safety cautions and radiation effects, is evolving to supply a healthier environment to mankind. Promising microwave applications in the future are related to the chemical industry, namely pyrolysis and recycling. Microwave pyrolysis application, which is already well understood and has the current status of being optimized, opens a possibility for production of many products from inputs such as bio/plastic waste (Fig. 3).

After a process enhancement in the area of batch systems, continuously working facilities for pyrolysis enabling future-proof and continuous provisioning with “green energy” in industrial scale are now being developed. One of the challenges here is the infeed of microwave energy into the process chamber, that has to be carried out via dirt-proof, atmosphere-separating window system within the waveguides. In other areas of the chemical industry, relevant for climate and environment, highly efficient microwave systems are used for heating processes during the production of extruded, bio-soluble plastic films of metal-free polylactic-acids and for the foaming and stabilization of polyurethane and melamine foams with a very low density that are used as heat and sound insulation.

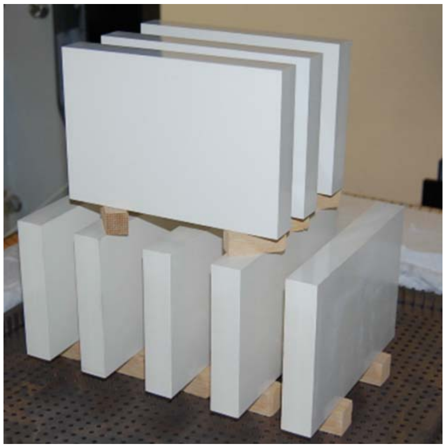

Figure 2: Sputter targets fabricated by MW debinding

Another future application is that of microwave recycling. In such systems, production of expensive fluorine species and new PTFE/PEEK materials is intended from unmixed recyclate of PTFE and plastics. Several high power microwave generators are used in fluidized bed reactors that are enriched with a susceptor material in a chemically high reactive steam atmospheric pressure to achieve a swift warming and reprocessing of the fluorine species.

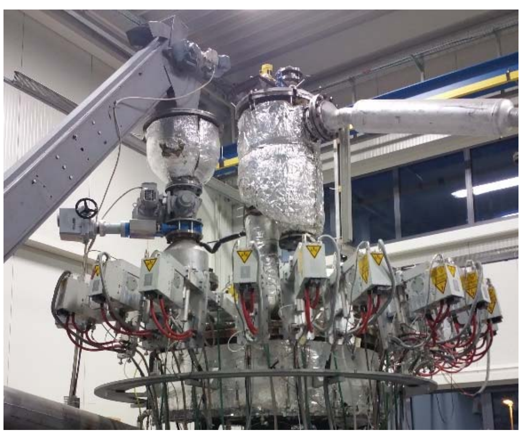

Figure 3: Microwave pyrolysis reactor (installed at Bionic Laboratories BLG GmbH, Germany, www.bionic-world.eu)

A further new area of application is the drying and hardening of fiber-reinforced composites directly during the production of fiber-reinforced composite profiles in the process of pultrusion, not in a batch process as hitherto (Fig. 4). The microwave located in the mold is utilized for a preheating and hardening of resins and coatings. Microwave technology is also the basis for integration with emerging plasma technology applications such as diamond growth. The microwave generator technology is expected to supply a preeminent consistency concerning the stability of frequency and performance over a long period of time that is essential for growing of crystals. A partitioned geometry of the resonator and an application of a specific wave propagation serves as an excellent plasma guidance and therefore offers outstanding results.

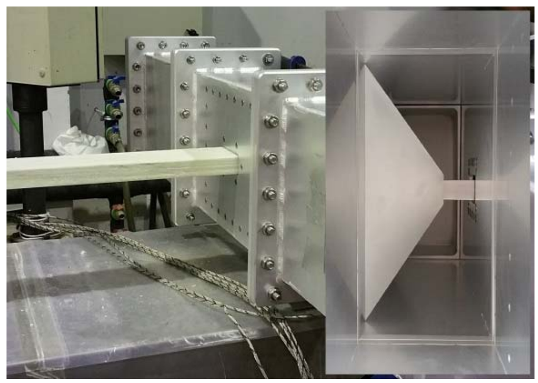

Figure 4: Microwave pultrusion die of fiber-reinforced profiles

Rephrasing the initial idea, miniaturized units are gaining acceptance in the market. Adapting to the concept, shrinking large standard components in microwave technology into small dimensions for size optimization and cost effectiveness has reently attracted much attention Furthermore, there future developments related to solid-state microwave components, establishing small-size and inexpensive solutions to all the previously discussed microwave applications. The main reason for the implementation of the solid-state technology is a fundamental minimizing of service costs thanks to omitting the magnetron tubes working with limited service life, in the power generators (Fig. 5). Interestingly, power ranges of 400 W can be achieved with 1-2 chip usage, which can be further amplified to 2-3 kW application with multi-chip arrays.

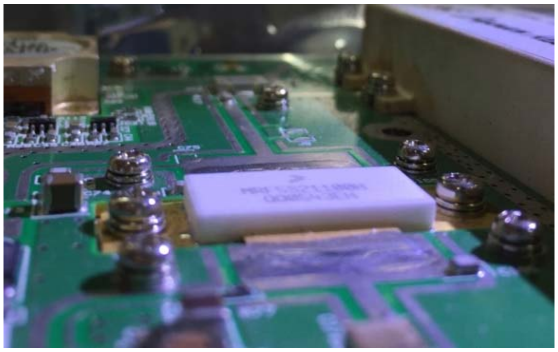

Figure 5: Microwave solid-state-amplifier

Conclusion

Industrial heating using microwaves is required for processing an emerging number of novel materials in a large variety of application areas. Different demands and specifications call for individual and customized solutions concerning coupling of the microwave energy to the material, necessary power level, and frequency to be applied. As the avoidance of downtime is more and more relevant, recent developments in solid state components will lead to an enormous booming of solid-state technology in microwave power supplies. Consequently, new concepts towards multi-channel processing based on solid-state power supplies will have to be developed for facilitating high-power microwave applications with this technology.

Acknowledgements

Part of the work related to the results referred to in this paper received funding from the German Ministry of Education and Research (BMBF) and from the European Commission. Funding was granted by the BMBF for the project "Miwelko" (Grant Agreement Number 13N8625) for the research into and the development of excellent plasma guidance based on a partitioned geometry of the resonator and on an application of a specific wave propagation, and by the European Commission within the Seventh Framework Program (FP7) for the projects:

- "InnoREX" (Grant Agreement Number 309802) for the research into and the development of highly efficient microwave systems for heating processes during the production of extruded, biodegradable polymers, and
- "COALINE" (Grant Agreement Number 609149) for the research into and the development of microwave application in the drying and hardening of fiber-reinforced composites directly during the production of fiber-reinforced composite profiles in the process of pultrusion.

It is also worth noticing that a more comprehensive presentation about the emerging applications of microwave technology with illustrative information likewise this article's content is planned to be presented at 16th International Conference on Microwave and High Frequency Heating: AMPERE 2017.

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About the Company:

Muegge GmbH is a solution provider in the field of industrial heating and plasma technology, offering solution packages and value added services with continuous improvement in quality and efficiency. The R,D&E Department of Muegge GmbH keeps close collaboration with customers to achieve product excellence, optimally matching the application needs. The department consists of 5 research teams, namely Power Electronics, Microwave Technology, Plasma Technology, Engineering and Funded Projects; working together to establish the basic understanding required to deliver a product according to the specified requirements and projects' scopes.

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