Microwave sintering of ceramics shaped by 3D printing

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Abstract: This PhD thesis deals with the sintering by microwave heating of alumina and yttria doped zirconia ceramics, shaped by additive manufacturing (Robocasting). Microwave heating allows to apply short thermal cycles with a moderate energy cost in comparison with conventional heating method. The combination of 3D printing and microwave sintering is a complete processing route, suitable for shaping and densification of small series of complex parts, saving raw material, time and energy. The aim of this work is therefore to reliably couple these two processes by improving our understanding of microwave/matter interactions, and by developing regulation methods and adapted sintering devices.

The methods of automatic regulation and temperature monitoring of microwave devices were first dealt with. The frequency instability of magnetron sources is an obstacle to the application of effective automatic control if it is not taken into account. Subsequently, the microwave coupling of alumina and zirconia was discussed. These two materials have a very different behaviour. Alumina, which is quasi-transparent, heats with difficulty under direct irradiation. Zirconia, on the other hand, has a behaviour that changes strongly with temperature, going from not very absorbent to reflective, making it difficult to control its direct heating. Taking into account the characteristics of microwave devices and the behaviour of materials, a method of assisted microwave heating is proposed, allowing the rapid and controlled sintering of parts with varied compositions and geometries. Complex parts have been successfully sintered using this process.