Experimental and Numerical Investigation of the Effect of Susceptor Arrangement during Single-mode Microwave Sintering

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Objectives

Testing the relevance of finite element simulation to control susceptor-assisted microwave sintering.

Materials & Methods

Sintering tests were carried out on TiO_2 compacted powder inside a 915 MHz single-mode cavity. Two SiC plates, set on both sides of the compact and parallel to the electric field, acted as susceptors (see Figure 1).

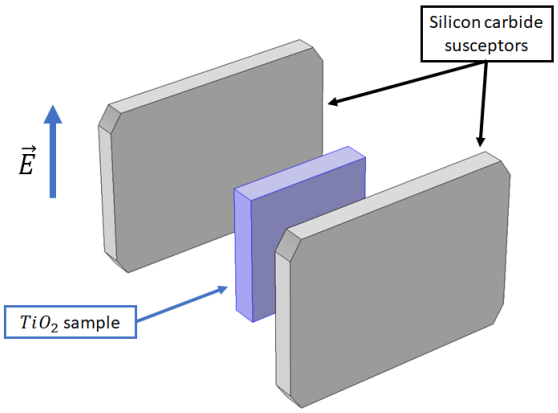

Figure 1: Element arrangement

Microwave sintering finite element simulations, including electromagnetic, thermal and mechanical coupling, were carried out with COMSOL Multiphysics® 5.3 software. Sintering deformation was described with a rough sintering model fitted from dilatometric tests.

Results

Two configurations have been tested: in the first one, the sample and the SiC plates were perpendicular to the electromagnetic wave propagation (aka Configuration 1) and in the second one the sample and the SiC plates were parallel to the electromagnetic wave propagation (aka Configuration 2). Whereas in Configuration 2, the TiO_2 shrinkage was homogenous, in Configuration 1, the sample tended to bend, evidencing the non-uniformity of shrinkage.

Numerical simulations showed that the two configurations result in very different heating processes. In Configuration 1, indirect heating occurs: the susceptors screen most of the electromagnetic field, so that the fraction of power dissipated in the compact is negligible. Concerning Configuration 2, the simulation revealed that the heating mode is similar to Configuration 1 at low temperature, while the heating gets hybrid at high temperature, as the dissipated power increases in the compact, due to TiO_2 dielectric losses increasing.

The difference in heating mode leads to different temperature distributions in the compact. In Configuration 1, the susceptor in front of the microwave generator catches a higher part of the electromagnetic power and reaches higher temperatures than the other one. This results in a very heterogeneous heating of the compact, which then exhibits a non-uniform deformation. In Configuration 2, the temperature is much more homogeneous, as it is usual in hybrid mode.

Conclusion

Numerical simulation proved to be efficient for a better understanding of susceptor-assisted microwave sintering. It is a helpful guide for designing susceptor configurations in the microwave cavity with a view to get uniform heating.