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# Energy Conversion during Microwave Sintering of a Multiphase Ceramic Surrounded by a Susceptor

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**A quasi-analytic model has been developed to examine energy conversion during the microwave sintering of a ceramic that is surrounded by a susceptor. Low-loss ceramics, such as $ZrO_2$, couple poorly with microwave radiation at low temperatures; however, because the dielectric loss usually increases rapidly as temperature increases, coupling improves dramatically at high temperatures. To improve heat transfer at low temperatures, susceptors are used. Three processes of energy flow are considered: microwave absorption due to dielectric losses, blackbody radiation, and heat convection. As expected, the susceptor (SiC) heats rapidly, relative to the ceramic ($ZrO_2$), at low temperatures; however, the ceramic attains higher temperatures after a prolonged period of microwave exposure. Below a critical temperature (800°C), the primary heat-transfer mechanism to the $ZrO_2$ is blackbody radiation from the susceptor. Above this temperature, microwave radiation is the main source that contributes to the temperature increase of the ceramic. The results of the simulation are in reasonable agreement with recent experimental data.**

role, because of (i) spatial discontinuities of the dielectric coefficient in various regions and (ii) rapid variations of the dielectric coefficient, as a function of temperature. Figure 1 shows a schematic illustration of the system. $ZrO_2$ is the ceramic to be sintered and is located in the center of the system; SiC acts as a susceptor, whereas $Al_2O_3$ acts as an insulator that confines the heat to the vicinity of the $ZrO_2$. Note that the analysis that follows is suitable for any low-loss ceramic when the dependence of the complex dielectric coefficient on temperature is known. For $ZrO_2$, SiC, and $Al_2O_3$, the dependence is shown in Fig. 2; this parametric dependence ($\varepsilon(T)$) tacitly will be assumed to be known, regardless of the physical or chemical mechanism that controls the specific behavior. The temperature dependence of the dielectric coefficient clearly has a major role in the energy-conversion process, either directly or indirectly via reflections. Our goal in this study is to determine the temperature dynamics (spatial and temporal variations) for all regions in space and examine the effect of geometric parameters; all the other variables can be established after the temperature is known.

Microwave radiation is the only source of external power; to