Multiphysics Modelling of a Microwave Furnace for Efficient Solar Silicon Production

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Abstract

The demand for silicon as the main raw material in communications and photovoltaics is steadily increasing. The conventional silicon metal production takes place in an electric arc furnace through a reduction of quartz (SiO2) with carbon (C) at temperatures of about 2,000°C. This is not only an energy-intensive process but also requires experienced operators. Furthermore, silicon metal has to be refined to solar silicon to meet the specifications of the photovoltaic industry. Therefore, it is necessary to develop alternative routes and methods to increase the efficiency of solar silicon production with a focus on energy consumption and product quality.
Microwave heating is an important industrial process and in recent years there has been an increasing focus on its applications. JPM Silicon is one of the leaders in producing and processing silicon for the solar industry using microwave heating. Therefore, it is of our interest to develop computer simulation methodologies to study the processes taking place within a microwave furnace.
For this purpose, several physics of radio frequency, heat transfer, and fluid flow are coupled using COMSOL Multiphysics® to examine critical features of a high efficiency microwave furnace. The model is numerically solved for various component configurations and materials. The solution provides details on fluid velocity, electric field, and heat distribution throughout the system (Figure 1). Moreover, experimental results are compared to the simulated model in order to evaluate its accuracy.

Figures used in the abstract

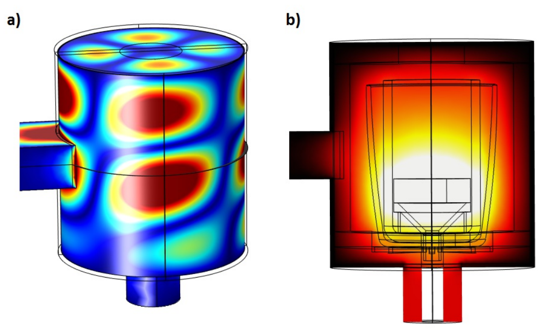

Figure 1: Distributed a) Electric Field, and b) Heat in Combustion Chamber.