INFLUENCE OF RADIATIVE HEAT TRANSPORT ON THE 3D UNSTEADY FLOW IN A DIFFUSION FURNACE

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ABSTRACT

Open tube furnace Boron diffusion is a possible large-scale manufacturing process for the formation of p^+-type regions for high efficiency silicon solar cells. Beside the impact of different diffusion parameters like gas composition, deposition time, the uniformity of the sheet resistance is strongly influenced by the flow transport of the dopant to the silicon wafer and the temperature distribution on the wafer surfaces.

A numerical study of the three-dimensional, unsteady transport phenomena in an open tube diffusion furnace loaded with a stack of 25 silicon wafers is performed. We used the highly efficient, parallelised DLR THETA code to solve the transport equations for mass, momentum and energy. Hybrid grids with up to 20 million points ensures a reasonable numerical resolution. Grid adaptation based on both the temperature and the velocity field is used to link high accuracy with numerical efficiency. The radiative heat transport from wall to wall is done using a Direct Transfer Radiation Method (DTRM) which is coupled at each time step with the Navier-Stokes solver.

The flow through the small gaps between the wafers is essential for the transport of the dopants to the surface of the silicon wafers. Due to the transverse arrangement of the wafers, the flow between the plates is small compared with the main flow through the furnace. Moreover, it stongly depends on the position of the wafer in the package. Fig. 1 shows the pattern of the main flow in the midplane of the tube. The isothermal flow is shown in the upper case of the picture. The incomming jet hits the first wafer at its center and an unsteady flow is observed around the wafer stack. If the furnace is heated, the cold jet drops down and the longitudinal flow concentrates at the bottom of the tube (see lower part of Fig. 1). The transversal flow between the thin wafers is shown in Fig. 2. In the isothermal case (left), the transversal component of the velocity is very small. Switching on the radiative heating, the hot wafers cause an upward flow (right). The overall flow rate between the wafers is increased and the transport of the dopants to the surface of the silicon plate is enhanced.

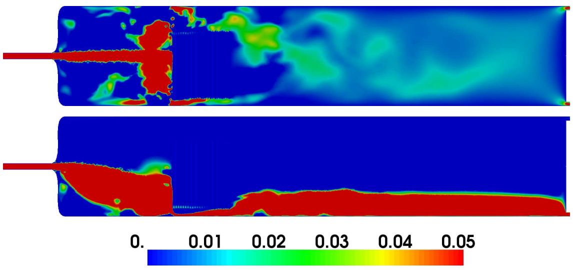

Figure 1: Contour plots of the x-component of the instantaneous velocity in a midplane of the tube

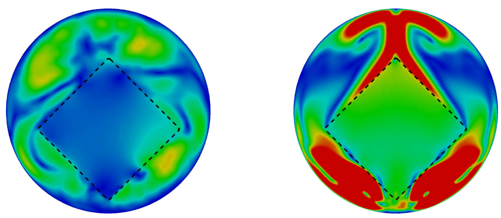

Figure 2: Contour plots of the averaged transversal velocity. The position of the wafers is indicated by the dashed lines.