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Micro-compression Filling Simulation Using the Stabilized Finite Element and Level Set Method

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Micro molding technology is a promising mass production technology for polymer based microstructures. Mass production technologies such as the micro injection/compression molding, hot embossing, and micro reaction molding are already in use. In the present study, we have developed a numerical analysis system to simulate three-dimensional non-isothermal cavity filling for the micro compression molding, with a special emphasis on the free surface capturing. Precise free surface capturing has been successfully accomplished with the level set method, which is solved by means of the Runge-Kutta discontinuous Galerkin (RKDG) method. The RKDG method turns out to be excellent from the viewpoint of both numerical stability and accuracy of volume conservation. The Stokes equations are solved by the Galerkin/least-squares (GLS) method using the equal order tri-linear interpolation function. To prevent possible numerical oscillation in temperature field we employ the streamline upwind Petrov-Galerkin (SUPG) method. With the developed code we investigated the detailed change of free surface shape in time during the mold filling. In addition, effects of various processing conditions are investigated by changing the upper and lower mold temperature, initial temperature of polymer substrates, and speed of compression. In the filling simulation of a simple rectangular cavity with repeating protruded parts, we find out that filling patterns are significantly influenced by the geometric characteristics such as the aspect ratio and pitch of repeating microstructures. The numerical analysis system enables us to understand the basic flow phenomena taking place during the cavity filling stage in microstructure fabrications.