Laser welding simulation of microfluidic devices

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Abstract

In this study, a numerical approach is presented for the simulation of the transparent laser welding process of thermoplastic polymers. In particular, the numerical tool is used to develop the welding process of a microfluidic device. The studied microfluidic device consists of two thermoplastic sheets, one of them has been previously micro-machined by a specific UV femtosecond laser setup. The assembly of the microfluidic device is then obtained by scanning a laser beam over its entire surface.
The weld quality of laser welded thermoplastics is strongly influenced by the amount of laser energy that is converted into heat, which also depends on the optical and thermal properties of the materials. In practice, finding suitable processes parameters for new products is often a difficult task given that temperatures at the interface need to reach the melting point without exceeding the degradation temperature of the polymer. Furthermore, the presence of micro channels in microfluidic devices modifies the heat absorption and heat transfer resulting in inhomogeneous temperature distributions at the weld interface.
The numerical approach followed here gives access to values that are difficult to measure experimentally, in particular the temperatures in the melted zone. The development of the process was carried out in steps of increasing complexity, from the study of the assembly of two plates without any micromachining to the analysis of the microfluidic device. Experimental welding tests are also presented and were carried out to validate the simulation observations and are also presented.