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Fabrication of microfluidic devices using ultrasonic welding: alignment, bonding & quality inspection

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Abstract

Purpose: Polymer-based microfluidic devices are well suited for inexpensive manufacturing but face new challenges in terms of sealing microchannels without liquid leakage and deformation of microstructures. Although techniques have been proposed such as thermal bonding and adhesive bonding, limitations (e.g. time-consuming and biocompatibility) prevent them from large-scale application. This study investigates the feasibility of ultrasonic welding as an alternative method for bonding thermoplastic microfluidic devices.

Methods: Bonding experiments are performed on a custom made ultrasonic welding machine. Uniform pressure distribution and alignment are taken into account by design of a self-leveling jig and fixture. Bonding tests are performed in triplet with a two-layer PMMA microfluidic device without the use of energy directors. Reference tests are performed to compare tests with longer bonding duration (32s) and higher ultrasonic amplitude (>60%). Furthermore, influence of plasma surface treatment and baking of the material before bonding is investigated.
Qualitative assessment of the bond quality is performed by visual inspection with focus on the uniformity of the bonded area and the degree of bonding. Quantitative assessment is based on the percentage of bonded area.

Results and Discussion: Low bonding forces (<300N) and long ultrasonic duration (>24s) are key in welding larger areas without creating completely molten deformed areas. The self-leveling jig provided a more uniform pressure distribution compared to the conventional jig. The bonding tests show a large variation in bonded area within repetition of the same experimental setup. Therefore no decision could be made on which change in parameter improves bond quality on a quantitative level. On a qualitative level, the largest difference in degree of bonding was observed between casted PMMA and extruded PMMA which can be explained by the difference in flatness of the substrates.

Conclusion: Ultrasonic welding is feasible as an alternative to common bonding techniques due to its short cycle times and localized heating of the joint area. However, more research is required to determine the influence of individual welding parameters on the quality of the bond.

Keywords – Bonding, Microfluidic device, Thermoplastic polymer, Ultrasonic welding

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