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Investigating stresses during laser welding of dissimilar materials: a thermomechanical modelling approach.

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In recent years there has been significant interest in the welding of optical materials to structural materials using ultrashort pulsed lasers. This has been propelled by the industrial demand for precision optical devices and the manufacturing challenges associated with conventional bonding processes such as adhesive bonding, including outgassing and contamination of optics.

During ultrashort pulsed laser welding, there are several key factors including laser parameters, surface preparation, bonding pressure, and thermal properties of the materials of interest which are critical to the success of the bonding process. Investigating and fine-tuning these process parameters and conditions to weld different shapes and material combinations is costly and time-consuming. Based on this premise, there is a need to develop both optical and thermo-mechanical models to investigate laser process parameters and laser welding techniques geared at alleviating thermal stress to maximise weld strength.

In this study, we consider the bonding of different optical materials such as quartz and borosilicate (BK7) glass to structural materials such as aluminium, titanium, and copper. A thermo-mechanical model is developed to investigate the influence of different thermal properties and laser scanning strategies on the stress and thermal distributions both during and after the welding of dissimilar materials. We have validated the results from the model by comparing it to measurements of polariscope stress fields from experimental work using the same material combinations.

Overall, the results from the model are in good agreement with the stress patterns observed experimentally, indicating that the model could be used to optimise laser parameters and scanning techniques, and to predict the stresses expected for a particular material combination and the dimensions of the parts to be welded.