Glass and silicon welding by femtosecond laser: set up improvement through modeling

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Abstract

In Photovoltaic and Microelectronics industries many devices combine materials of different physical and mechanical properties such as silicon and glass are used. Welding them is a complex application that still can be improved in terms of speed, preservation of mechanical properties.
Conventional welding methods (anodic fusion, adhesive bonding, and junction by fusing, optical contacting) and continuous laser welding are relatively effective but can be improved in terms of machining speed, thermal and chemical resistance, seam limited length, long term stability, complex pressure tools....

In this work a femtosecond laser emitting at 1030 and 515 nm is used to weld both glass on glass (sodalime, borosilicate, aluminosilicate) and glass on silicon (mono and polycrystalline). Different ranges of thickness are tested for glass plate (from 0.7 to 2 mm) and for silicon wafer (from 100 to 300 μm).

Power, pulse duration, frequency, beam diameter focussing and process speed are the key parameters to empower this application. Even with few values for each parameter, the number of experimentations can be tremendous. To reduce with efficiency the time to provide good beads and to optimise the machining speed, numerical modelling is combined with experiments works. Different welding trajectories and strategies configuration (with or without mechanical pressure, parts roughness) are tested.

Finite element method (FEM) calculation based on laser beam set up is used to model the melted zone morphology. Transient thermal calculation is done to analyse temperature field.

These numerical works help to optimise focus plane, power and machining speed ranges.

Numerical results analyses led to understand melting temperature is reached from the 6th pulse.

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Different welding strategies led to reach 3 m/s machining speed for glass on silicon welding.
Heat treatments reveal that welded samples resist to 200 ∘C thermal shock while the beads are still watertight.

Keywords: Finite Element Method, Laser beam, laser welding, welding trajectories, welding strategy, soda lime, borosilicate mono and polycrystalline silicon wafer, residual stresses and modelling