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High yield ultrafast laser microwelding process for direct joining of metal-to-glass

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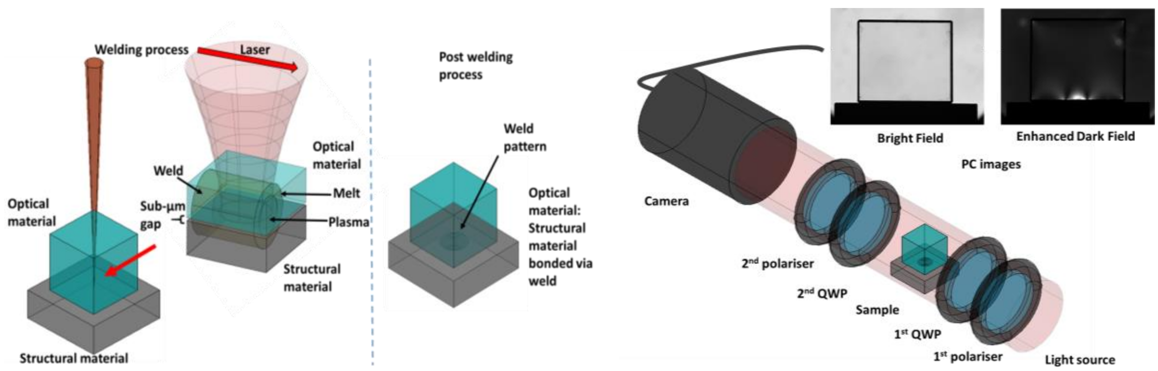
The vast majority of manufactured goods are made out of more than one material, in order to provide the desired material properties and function. A common manufacturing issue is thus the bonding of materials with highly dissimilar properties, for example joining a structural material such as a metal to a functional material, e.g. glass or ceramic that provides particular optical, thermal, or electronic properties.

Metal-to-glass assemblies are used in a number of manufactured products, e.g. cars, lamps, scientific instruments, etc. In current manufacturing, bonding such highly dissimilar materials normally involves an interlayer, for example an adhesive, solder or frit, capable of bonding to both material surfaces. Such indirect bonding techniques have issues with regards to reproducible absolute component positioning, and also there is always the risk of unwanted contamination (by the interlayer material) of other surfaces. Furthermore, adhesive bonding is generally the simplest technique to implement but it suffers from outgassing, aging, and creep. A technique that could be used to directly bond such highly dissimilar materials is thus highly attractive.

Ultrafast laser microwelding has been demonstrated to be such a method [1, 2]. The joining process is driven by irradiation of the desired weld interface using picosecond or femtosecond laser beam, tightly focused through the glass. In our case we have employed a Trumpf picosecond laser system (5.9 ps, 400 kHz at 1030 nm). The tight focus enables a simultaneous combination of linear absorption on the metal surface and non-linear absorption within the glass component. A small plasma forms surrounded by a melt region of typically few hundred micrometers thick. It is important to select laser parameters that have sufficient pulse energy to drive non-linear absorption in the glass and to create a plasma, and sufficient average power to create a sufficient melt volume to create a strong weld.

In order to transfer this process to industry it needs to be very repeatable and highly reliable. In this presentation we therefore report studies on the surface finish requirements of components to be bonded in order to obtain a high yield. We evaluate bonding strength between components for different surface finish combinations and investigate (through polariscopic measurement [3]) the effect of stress induced by the welding process on the optical properties of glass component. Our results are compared with those of components bonded via a standard adhesive bonding technique.



(a) (b)

Figure 1. a) Principle of ultrafast laser welding process for dissimilar materials; b) Polariscope set-up used for investigation of the stress induced in optical material after ultrafast joining along with example of the bright field and dark field images (100 × amplified image sensitivity)

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