Ultra-Short Pulse Laser Welding of Quartz Crystal

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Ultra-short pulse laser welding has attracted significant interest as a method for bonding optical materials to themselves, structural materials, or to other highly dissimilar materials. This is largely due to its ability to weld with a highly localized heat affected zone (HAZ) surrounding the bond, and without the need for intermediate layers or extra material. This can address a growing industry need for the manufacture of high precision optical and electronic devices which do not degrade over time due to outgassing of adhesives, which are conventionally used to fix components.

The welding is made possible by ultra-short pulses which limit the interaction times and give access to nonlinear absorption in otherwise transparent materials [1]. It is therefore possible to focus the laser through the transparent material to a location near the bonding interface. This allows for precise control over the location and quantity of energy deposited. Due to the high intensities a plasma is readily formed in the focal region from both materials. Once the laser irradiation has passed, the plasma cools and resolidifies creating a bond across the material interface [2].

Many devices utilise the properties of crystalline materials which arise out of their ordered structure, such as birefringent or diffractive optics. Ultrashort-pulse laser welding is an excellent candidate for manufacturing these due to the small HAZ, which allows direct bonding while limiting detrimental effect on the essential crystal structure. In this study we develop and optimise a welding strategy for direct welding of quartz to quartz, which considers the effect of welding counterparts of different crystal orientation. Also considered is the effect of laser parameters on the welding of these differently orientated crystals, and whether the resulting crystal microstructure can be controlled.

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[1] Tamaki, T., W. Watanabe, and K. Itoh, Laser micro-welding of transparent materials by a localized heat accumulation effect using a femtosecond fiber laser at 1558 nm. Optics Express, 2006. **14**(22): p. 10460-10468.

[2] Carter, R.M., et al., Picosecond laser welding of similar and dissimilar materials. Applied Optics, 2014. **53**(19): p. 4233-4238.