Ultrafast laser microwelding of ultra-thin flexible glass

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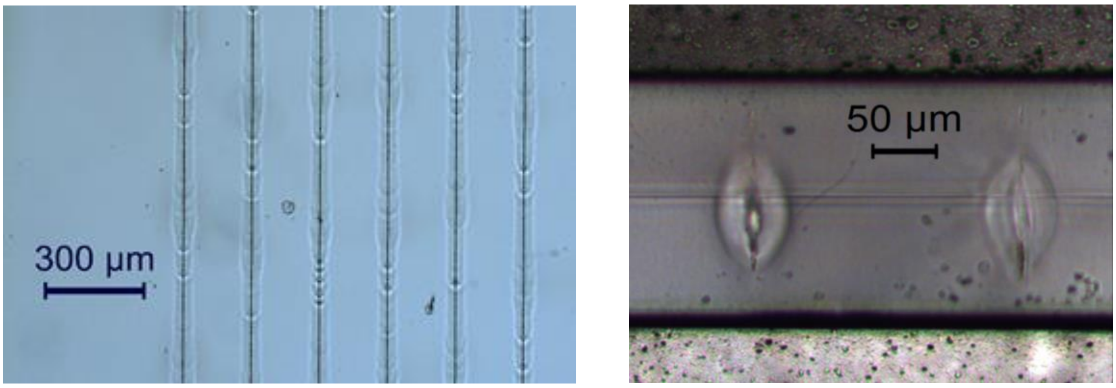
The constant evolution of the opto-electronic device industry imposes an increasing requirement for hermetic, durable and high accuracy encapsulation capabilities. In particular, OLEDS are highly sensitive to moisture and oxygen ingress which has led to lifetime issues. Flexible glass is an attractive encapsulation material, combining excellent hermeticity with high transparency and the ability to conform to a curved surface. However an interlayer (e.g. polymer) is normally required to seal around the encapsulated device, which can result in hermeticity problems. Direct welding of the flexible glass package is therefore an attractive option, and we have demonstrated that this is possible using an ultrafast (picosecond pulsed) laser.

This process relies on the very high peak intensity from a laser beam that is tightly focused through the top sheet of glass to provide a focal spot in the vicinity of the glass-glass interface. Non-linear absorption results in the generation of free electrons in a highly localised focal volume, leading to plasma formation [1]. For a successful weld, the laser pulse repetition rate has to be sufficiently high to also provide thermal accumulation, resulting in a localised melt volume (heat affected zone (HAZ)) surrounding the small plasma. The size of this HAZ depends on the laser parameters used and can be modified to be smaller than 100 µm. As the laser spot translates across the material, this highly localized melt zone solidifies behind the beam and forms a strong bond (microweld) between the two surfaces.



(a) (b)

Figure 1. Optical microscope images of the weld features in two 100 µm thick flexible glass components obtained by ultrafast laser microwelding (a) Top view of a series of welds; (b) cross section of the weld seam

In this paper we report studies of interlayer-free ultrafast laser microwelding of two 100 µm thick flexible glass sheets using a Trumpf picosecond laser system (5.9 ps, 400 kHz at 1030 nm). Since the ultrafast laser microwelding processes requires that the two surfaces are brought into close contact, we investigate the maximum allowed gap between those two components in order to obtain a successful weld. We also evaluate the strength of the welding seam by tensile stress measurements (3-point bonding test). Our results are compared with those of components bonded via a standard adhesive bonding technique.

We acknowledge financial support from Innovate UK under grant No. 103763, UltraWELD.

[1] J. Chen, R.M. Carter, R.R. Thomson, and D. P. Hand, Avoiding the requirement for pre-existing optical contact during picosecond laser glass-to-glass welding: erratum, Optics Express Vol. 23, Issue 21, pp. 28104-28105 (2015).