The principles of ns pulsed fiber laser welding process that enable it to solve challenging welding problems.

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From a laser joining perspective, there are multiple challenges that make joining of thin materials and dissimilar material combinations exceptionally challenging. For successful joints there is a need to avoid over-penetration, distortion and warping; all of which relate to the need for careful control of the heat input of the process. TRUMPF's TruPulse nano range of pulsed fiber lasers offer an innovative solution to some of the challenging joining problems faced by industry. Despite the ns welding process being widely used, its mechanism and properties are not understood.

A single ns pulse has not enough pulse energy to generate any significant melt volume. Moreover, the mechanisms of material processing are significantly different between ns pulses and CW/long pulse duration beams. During a traditional laser welding, melting and evaporation phenomena are dominant whereas melt ejection is responsible for material removal during nanosecond interaction. Therefore, a different mechanism is used to achieve joining with ns pulses. A single spot can only penetrate a few microns into the material and so multiple pulses delivered at high repetition frequencies are required which effectively drill into the material building up heat locally and eventually create a micro keyhole. This keyhole is very different to that of a conventional cw laser weld. This high intensity drilling process can generate capillary keyholes that have an incredibly high aspect ratio that are more akin to electron beam welds than conventional cw laser welds.

It was believed that much of the energy of many pulses is accumulated and used to vaporise material of which a significant amount recondenses within the keyhole. The amount of melt is extremely limited which leads to minimal mixing which is particularly important in the joining of dissimilar materials. However, recent studies have found that the process dynamics are far more complex, and a significant mechanism is that of phase explosion where material from the base of the keyhole is ejected up through the capillary as molten droplets that deposit themselves on the capillary walls. The temporal pulse shape can influence the material removal mechanisms and determine the ratio between energy used for vaporisation, melt explosion and conduction into the bulk material.