Machining of Through-Glass Vias (TGVs) with femtosecond laser GHz burst modes

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Through-Glass Vias (TGVs) are critical components in today's semiconductor and electronics industries, enabling the creation of high-density interconnections in a wide array of devices, from the smartphones sensors in cars, and intricate Micro-Electro-Mechanical Systems (MEMS) that power various technologies [1]. By facilitating vertical electrical connections through glass substrates, TGVs are required in the ongoing drive towards device miniaturization, contributing to the enhanced performance of electronic packages. Using femtosecond laser pulses, it is possible to drill transparent materials such as glass with minimal thermal effects, however, depending on the thickness of the substrate, thousands of pulses may be required to form a well-defined TGV. Therefore, finding an approach that can maximize the efficiency of drilling such structures is highly sought-after.

In this work we present our findings in percussion drilling tests performed by femtosecond laser burst modes in the GHz regime (sub pulses within the burst are separated by ~400 ps), targeting a variety of transparent materials including glass, fused silica, diamond, silicon carbide and sapphire. The results show that employing burst modes, particularly with a higher number of sub-pulses (up to a few hundred), significantly deepens the micro-machined channels within these materials. Using the burst modes, it was possible to reach a higher depth compared to the conventional single pulse case. This effect was assessed for different materials, showing varying degrees of efficiency. Our experiments demonstrate that by using GHz burst modes it's possible to drill channels in glass spanning several millimeters deep. Moreover, the channels show signs of good quality which is superior to the traditional single-pulse micro-machining case.

The results of our research showcase the increase micromachining throughput of TGVs and show the versatility of these techniques for a range of materials beyond traditional applications. While TGVs are commonly utilized in electronics for interconnects, our findings suggest that employing femtosecond laser GHz burst modes can facilitate the development of TGVs and deep micro-machined channels in various materials. This enhances the depth and quality of the machining but also suggests possibilities in fields like advanced optics, biomedical devices and others.

References: [1] Kim, J.; Kim, S.; Kim, B.; Choi, J.; Ahn, S. Study of Through Glass Via (TGV) Using Bessel Beam, Ultrashort Two-Pulses of Laser and Selective Chemical Etching. Micromachines 2023, 14, 1766. https://doi.org/10.3390/mi14091766