Study of Selective Laser-induced Etching for Micro-hole Formation in Glass using a Bessel Beam

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TGV (Through Glass Vias), envisioned as the next generation of TSVs (Through-Silicon Vias), is rapidly emerging as a pivotal factor in 3D-semiconductor packaging. Selective Laser-induced Etching (SLE) presents an exceptionally precise method for micro-hole formation due to the high aspect ratio, high density and high throughput [1]. To achieve a high aspect ratio with the desired hole size of a few 10 μm, it is crucial to consider the material composition of the glass, the appropriate conditions of the etchant, and the laser processing conditions [2].
In our research, we conducted a process parameter study to identify factors affecting the selectivity of Schott D263® T eco glass substrates in order to improve geometrical hole quality and etching productivity. A picosecond infrared (IR) laser is employed with Bessel beam optics to create localized modifications through the entire glass thickness. This modification results in changes to stress distribution and refractive index, as well as to the formation of voids and volume expansions in the confined area. For the laser processing condition, the diameter of the Bessel beam and the pulse energy were used as variables. Following laser modification, we immersed the glass samples in HF, KOH, and NaOH solutions to observe the differences in selectivity depending on the etching agents or the concentration of the solutions. The specimens were then examined by both Optical Microscopy (OM) and Scanning Electron Microscopy (SEM). This parametric study allows for optimization of the SLE process for achieving micro-holes with a hole wall taper angles close to 90°.
This study enabled us to understand the initialization of the SLE phenomena in glass by using a Bessel beam and contributed to developing high aspect ratio TGVs with the improvement of selectivity. Furthermore, as we align with demand for the high throughput in TGV manufacturing, it's crucial to enhance the process efficiency, especially regarding tact time. Our next effort is focused on developing high-speed laser processing techniques based on this study.

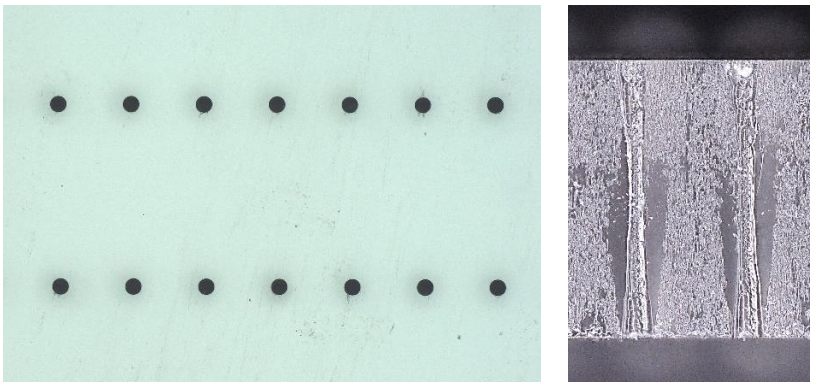

Figure 1. Mirco-holes after etching (a) OM image of glass top surface, (b) Cross-sectional image

References: [1] Butkutė, Agnė, and Linas Jonušauskas. "3D manufacturing of glass microstructures using femtosecond laser." Micromachines 12.5 (2021): 499.; [2] Yonemura, Masatoshi, et al. "Formation of through holes in glass substrates by laser-assisted etching." Journal of Laser Micro Nanoengineering 11.2 (2016): 143.