Advances in micromachning for through via drilling with femtosecond laser operating in burst-mode

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Femtosecond GHz-burst mode laser processing of glasses and silicon has attracted much attention in the last few years showing enhanced ablation rates when well choosing the laser burst parameters [1-2]. Especially, top-down percussion drilling has been demonstrated in different dielectrics with outstanding surface quality of the inner walls and featuring almost cylindrical holes with aspect ratios of up to 150. However, there is a big interest in drilling through vias in glasses (TGV) and semi-conductors, especially in silicon (TSV), as these materials are of extreme interest for applications in microelectronics. In this contribution, we present through via drillings in these materials with a femtosecond laser operating in different GHz-burst and MHz-burst regimes. Our study reveals certain constraints and limits depending on the material characteristics and on the laser parameters. There is a significant difference between the outlet diameter (see Figure 1) that could have been obtained (right) and the one that is actually obtained (left). This observation seems to validate the hypothesis made in [3] that the plasma within the hole plays a crucial role in the drilling process in GHz-burst mode. We show how to overcome these limits and suggest a hypothesis of the drilling process dynamics. Finally, we demonstrate through via drilling results of excellent quality and constant diameter in both glasses and silicon.

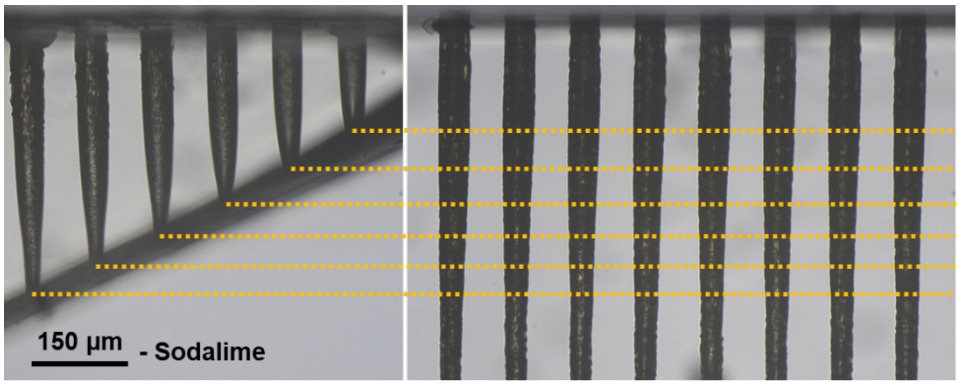

Figure 1: Microscope images of holes obtained in a bevel sample in sodalime (left) and in a reference sample (right). The holes were drilled under exactly the same conditions.

References: [1] C. Kerse, H. Kalaycoglu, P. Elahi, B. Cetin, D. Kesim, et al., Nature 537, 84–88 (2016). [2] P. Elahi, O. Akçaalan, C. Ertek, K. Eken, F.O. Ilday, et al., Opt. Lett. 43, 535-538 (2018). [3] P. Balage, J. Lopez, G. Bonamis, C. Hönninger, I. Manek-Hönninger, Int. J. Extrem. Manuf. 5, 015002 (2023).