Advanced Ultrashort Pulsed Laser-Enabled Direct-Write Techniques for Nanofabrication and Microfabrication

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Laser-enabled direct-write technology has emerged as a pivotal advancement in the fabrication of microelectromechanical systems (MEMS) and extends its utility to broader applications in nanofabrication and microfabrication. Traditional photolithographic processes, constrained by the need for physical masks and limited flexibility, have impeded rapid prototyping and innovation in these fields. Our approach, leveraging ultrashort pulsed lasers, transcends these limitations by facilitating precise subtractive and additive manufacturing without the requisite for masks. This method enables the creation and modification of features at the micron and submicron scales with high repeatability and enhanced quality through the integration of gas-assisted processing and advanced beam manipulation techniques.

In the current study, we employ a femtosecond laser combined with targeted gas injection and innovative masking to produce features with quality and precision comparable to focused ion beam (FIB) systems but at significantly reduced time and cost. This technique allows for the efficient production of large cross-sections and complex structures necessary for advanced device fabrication. We demonstrate the versatility and effectiveness of this technology through detailed comparisons of feature fabrication in materials such as silicon and copper, underlining the superior edge quality and minimal material redeposition achieved.

Our findings indicate that laser-enabled direct-write technology not only accelerates the development cycle but also opens new avenues for application by enabling the creation of complex, high-precision structures. These capabilities are crucial for advancing current manufacturing paradigms in semiconductor and electronic device production, as well as biomedical device manufacturing, to name a few, offering a rapid, flexible, and cost-effective alternative to conventional fabrication techniques.

References

[1] May, N., Choi, H., Phoulady, A., Amini, S., Tavousi, P., & Shahbazmohamadi, S. (2023). Gas-assisted femtosecond pulsed laser machining: A high-throughput alternative to focused ion beam for creating large, high-resolution cross sections. Plos one, 18(5), e0285158.

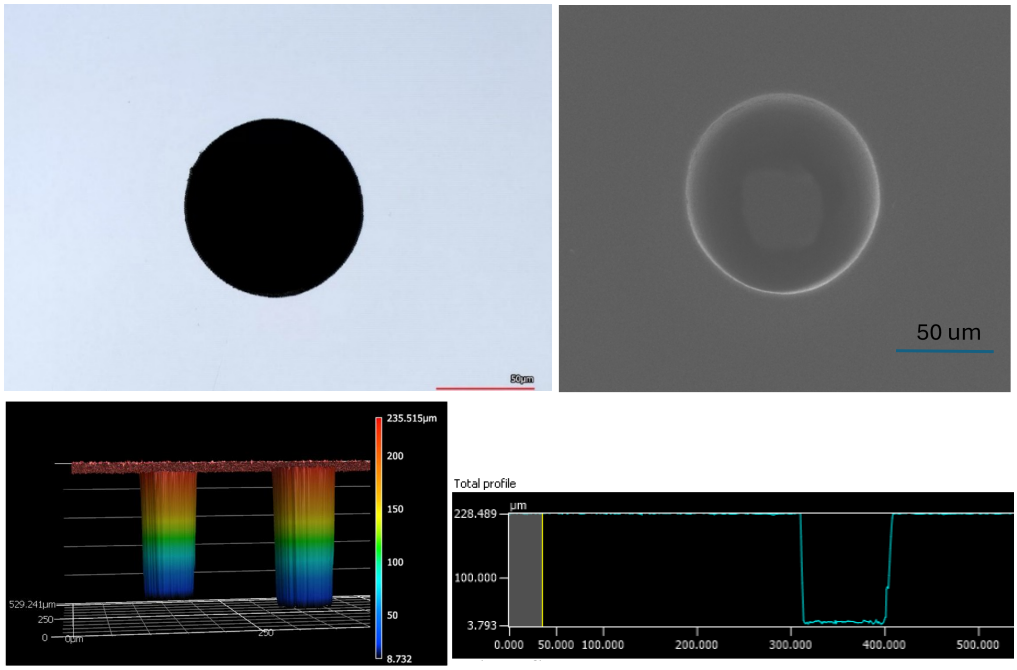

Figure 1: Multimodality analysis of holes drilled in silicon using the proposed laser-enabled direct-write approach.