Fianium

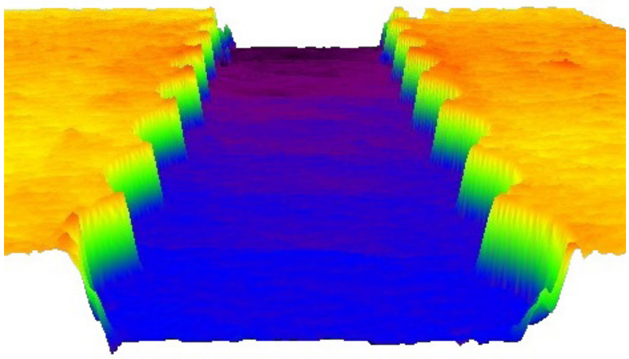
NEW APPLICATION NOTE

Picosecond Pulsewidths Provide Improvements to Thin Film Microprocessing

Thin film scribing and patterning are applications particularly well suited for picosecond lasers. These applications require only moderate pulse energy and often significantly benefit from the short interaction time between the material and pulses through enhanced efficiency, lower ablation threshold, improved quality, or increased process capability. For example, the ultra-high peak power associated with ultrashort pulses enables single-pulse lift off processing of transparent films through nonlinear absorption of the laser energy.

Fianium's high energy picosecond fiber lasers produce pulse energies up to 125 µJ with incredibly high peak powers, which make them cost-effective tools for high-throughput thin film processing. They provide the capability of inexpensive, maintenance-free, virtually defect-free scribing and patterning of virtually any thin film material at rates exceeding 5000 mm/s. The unmatched quality and speed of thin film scribing and patterning coupled with enhanced capabilities makes Fianium's picosecond high-energy lasers the ideal tools for such processes.

- Up to **125 µJ** pulse energy and **25W** average power
- Picosecond and femtosecond pulse widths
- Single-shot to **40MHz** variable repetition rate
- **1064 nm** or **532 nm** wavelength
- Designed for **24/7** operation and OEM integration
- Maintenance-free



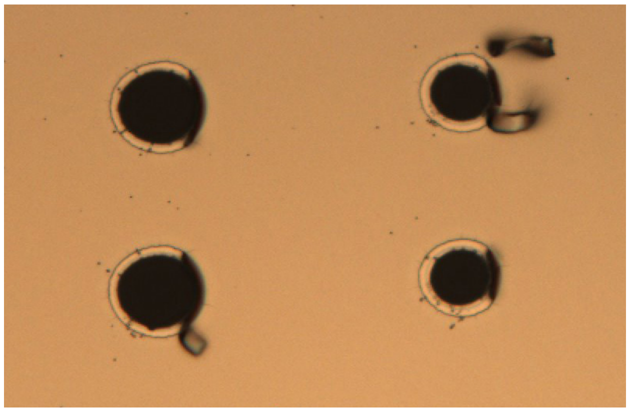
3D image of molybdenum metal film on glass selectively removed using a picosecond fiber laser from Fianium

Applications Lab

Fianium's application lab in Portland, Oregon is available for clients to evaluate the effectiveness of Fianium lasers for their custom application. We offer a host of micromachining application capabilities including but not limited to thin film processing.

Improvements in Laser Processing of Thin Film Materials with Picosecond Pulsewidths

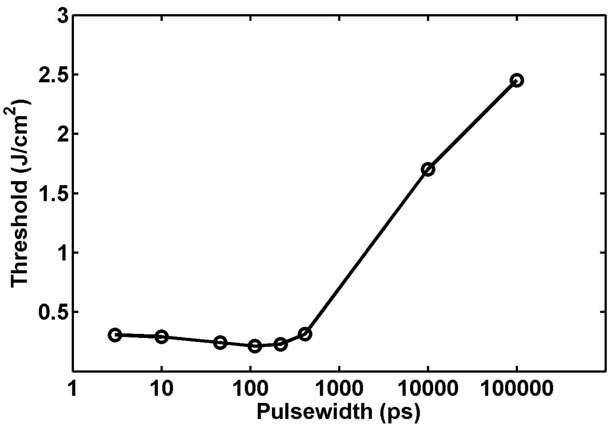
Ultrafast lasers are the tools of choice for a number of thin film microprocessing applications. Such applications generally involve thin films of metals, polymers, and dielectrics that can be susceptible to adverse heating affects, like melting, peeling, chipping, melt splatter and substrate damage. The figure to the right demonstrates one such defect that can occur in thin film microprocessing with nanosecond lasers. In the image small bits of material are peeling off around the edges and protruding vertically from the film surface. For conductive materials this sort of defect is often catastrophic for device functionality.



Single pulse material removal by 10ns pulses demonstrating chipping defects

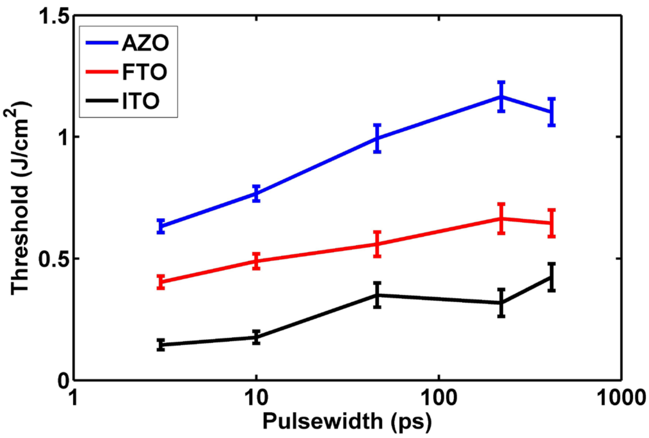
Process quality can be significantly improved through the use of ultrashort pulse lasers such as Fianium's picosecond fiber lasers. The figure at the bottom demonstrates backside (through the glass) processing results for 3ps, 46ps, 10ns, and 100ns from left to right respectively. The picosecond results are defect free and uniform, while the nanosecond results suffer from chipping and significant melting and severe material splatter. The 10ns result shows chipping around the edges and one such example can be seen on the left edge of the scribe just below center. What is difficult to observe from the images but is also present is substrate microcracking occurring in the nanosecond results.

In addition to avoiding heat related defects, ultrashort pulsewidths can also improve processing results through increased process efficiency. The long interaction time associated with nanosecond lasers causes more energy to be wasted as heat results in melting and diffuses out of the modification area. Ultrashort pulses, on the other hand, have such short interaction times that all of the energy applied by the laser pulses is directly utilized in the ablation mechanism and is thus a more efficient process. The plot of measured removal thresholds below demonstrates that in the picosecond regime the removal threshold of thin molybdenum films is around 0.25 J/cm^2. When the pulse length increases into the nanosecond regime the threshold increases by an order of magnitude, requiring an order of magnitude more pulse energy than the picosecond case for the same removal area.



Molybdenum film removal threshold as a function of laser pulsewidth. Threshold is mostly constant for the picosecond results, but increases by an order of magnitude in the nanosecond regime.

Ultrashort pulsewidths are also important for applications involving nonlinear absorption where peak power is key. Typically UV wavelengths are required to remove materials such as transparent conducting oxides (TCOs), but with the incredible peak powers provided by ultrafast pulses green and even IR wavelengths are effective for removal. Ultrashort pulsewidths also increase process efficiency for TCO ablation, just like in the case with metal films. The figure below demonstrates that the removal thresholds increase with pulsewidth for three different TCOs of different thicknesses. This trend again demonstrates an increase in process efficiency with shorter pulsewidths.

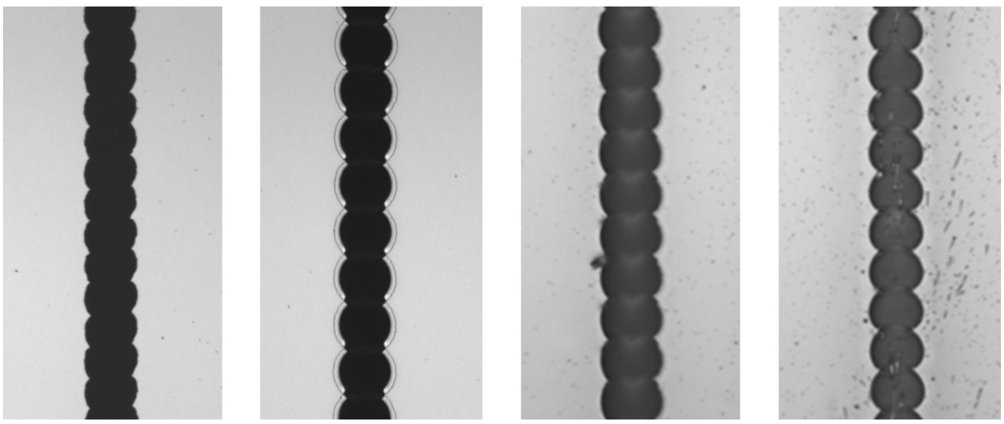


Transparent conducting oxide (TCO) film removal thresholds as a function of laser pulsewidth for three TCO types of various thicknesses. Required pulse energy for film removal is observed to increase with pulsewidth.

Summary

We demonstrated here the contrast between nanosecond processing, which often suffers from detrimental heat-related affects, and the cleanliness and athermal processing of picosecond pulses. We also demonstrated a propensity for ultrashort pulses to increase process efficiency. The material removal efficiency of both metal and transparent films was shown to be better in the picosecond regime than in the nanosecond regime. Overall, both the quality and the efficiency of thin film material removal with picosecond pulses is typically superior to that of the nanosecond regime and demonstrates that picosecond lasers are often a preferred tool for thin film material removal.

This note generally discusses possible uses for Fianium products. Your use could require licensing of intellectual property, depending on the details of the system you assemble or particular method you practice. You are solely responsible for obtaining any such licenses and for any infringement should you fail to do so.



Scribes of molybdenum thin films on glass created using various picosecond and nanosecond fiber lasers. The pulsewidths are 3ps, 46ps, 10ns, and 100ns from left to right. Significant heat-related defects, such as melting and chipping, are observable in the nanosecond results, while the picosecond scribes are fully defect-free.