Optimizing Laser Ablation of a Silicon Specimen via microPREP

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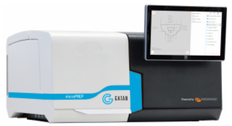
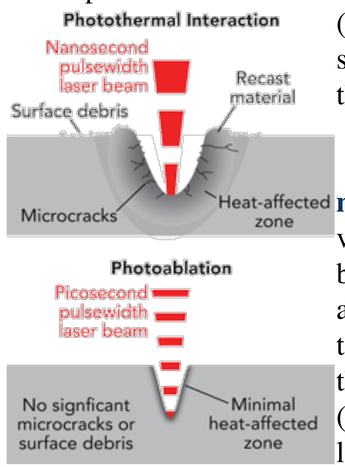
INTRODUCTION

Gatan's microPREP machine utilizes laser ablation technology to significantly reduce the time it takes to prepare a specimen for observation. By using picosecond laser technology, microPREP executes a cleaner cut in a shorter period of time to minimize time spent with the ion beam.



BACKGROUND AND SIGNIFICANCE

Picosecond lasers are a type of laser with picosecond long pulses, providing extra benefits over past technologies (Paschotta, n.d.b). They directly target the bonds between atoms, and fire photons to break these bonds (Paschotta). This process (**photoablation**) atomizes the molecules and is "**cold**", which prevents the surrounding area from being damaged (Paschotta). This results in more sample being unaffected and therefore viable for examination.



Previous technology used **nanosecond lasers,** which vaporized material. This causes burn damage to the surrounding area and requires further preparation to remove the burned material so the sample is viable for analysis (Paschotta & High). Picosecond laser technology minimizes the heat affected zone and is more efficient and clean overall.

Clean and observable samples are crucial for a wide variety of fields. It allows car designers to better analyze their steel alloy to determine the best composition to make their cars with. It allows silicon wafers for semiconductors to be more closely analyzed and improved. It allows pharmaceutical companies to analyze their pill casings to design better deliveries. The applications of sample preparation and analysis are widespread.

RESEARCH METHODOLOGY AND DATA

Objective:

Initial trials manipulated power in order to ensure that differences could be observed because we felt confident that power would be a deciding factor in final cut quality. We then tested vector direction (unidirectional vs bidirectional), spot diameter (diameter of the laser spot), pulse distance (distance between each pulse of energy) to see if similar results could be yielded.

SEM Images at 5,000x Magnification

Power Level (Watts)	Power	Unidirectional	Bidirectional
.15			
.45			
.75			

Distance (microns)	Spot Diameter	Pulse Distance
5		
10		
15		

DATA ANALYSIS AND RESULTS

Analysis of SEM Images

Cut quality was determined by estimating the dark area of each picture, indicating a less elevated position as well as less redeposited silicon. The brighter parts represent more redeposited silicon.

For power, we determined which 5000x image had the smallest percentage of dark area (**0.15 W**). The optimal setting for spot diameter was **15 µm** because the laser began overlapping with previously ablated areas, essentially cutting the same area twice. The pulse distance appears to have the least silicon residue when the pulse distance is **15 µm**, making 15 µm optimal for both parameters . Additionally, the vector direction parameter did not appear to affect the amount of silicon redeposited.

Discussion

By testing the following laser parameters: power, vector direction, spot diameter, and pulse distance we were able to optimize the process of cutting a silicon wafer. We found that a power level of .15 W, spot diameter of 15 microns, and a pulse distance of 15 microns appears to produce the cleanest sample. While, the SEM images gave a relatively clear image, the only available view was bird's eye. This meant no cross section of the redeposit ion could be obtained, which would potentially have made interpretation of our results much easier.

ACKNOWLEDGEMENTS AND REFERENCES

Special thanks to Sander Gubbens, our mentor, for helping make this project possible.

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