Boeing – Laser Surface Smoothing Optimization

Team: Braedan Clay[1], Lauren Davis[2], Andrew Newman[2], Bao Son[2]
Mentors: Luna Huang[1], Kady Gregerson[3], Alex Hicker[3], Matt Johnson[3], Megan Taylor[3], Vidyaaranya Macha[2]
[1]UW Materials Science and Engineering, [2]UW Mechanical Engineering, [3]The Boeing Company

Abstract

This project explores the possibility of smoothing out the layer lines and stair steps of 3D printed parts using a near-infrared laser. 3D printed parts that are printed at small angles tend to form increasingly large stair stepping layer lines. This is problematic, as sanding down the layers and stair steps to prepare the parts for painting wastes valuable time. We aim to bypass this by using a laser to ablate and create a smoother surface. In this project, we developed a set of laser parameters to use on flat ABS samples including dosage, irradiance, and pulse duration. We then iteratively optimized these parameters and finally applied them to angled, stair-stepped samples.

Background

- Boeing intends to 3D-print parts for interior decorative use.
- Prior to painting, these parts require post processing, including sanding, filling, and priming.
- Sanding is ergonomically challenging as well as time consuming.
- We aim to eliminate the sanding process and replace it with laser ablation for material removal and smoothing.

Methodology

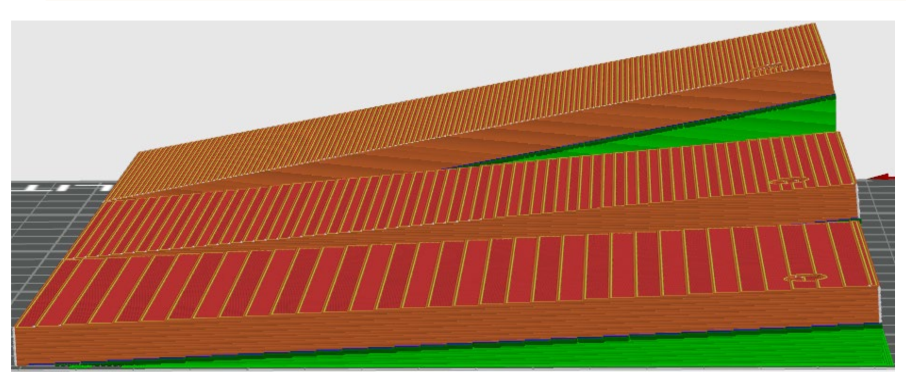

Figure 1. 3D printing slicer view of angled coupons highlighting the stair step lines.

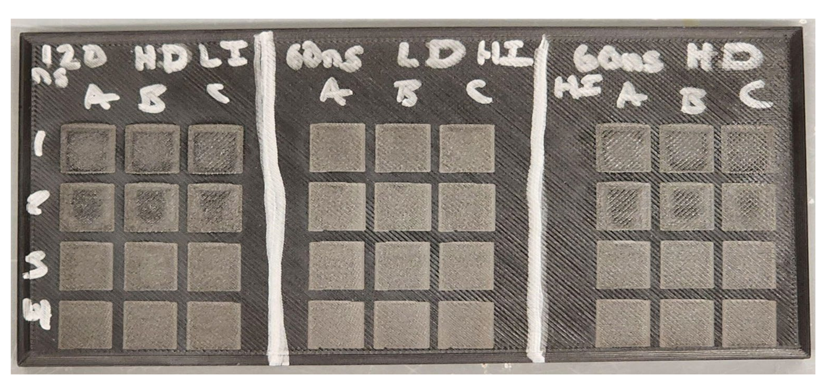

Figure 2. Flat ABS sample with variety of laser parameter trials for parameter optimization.

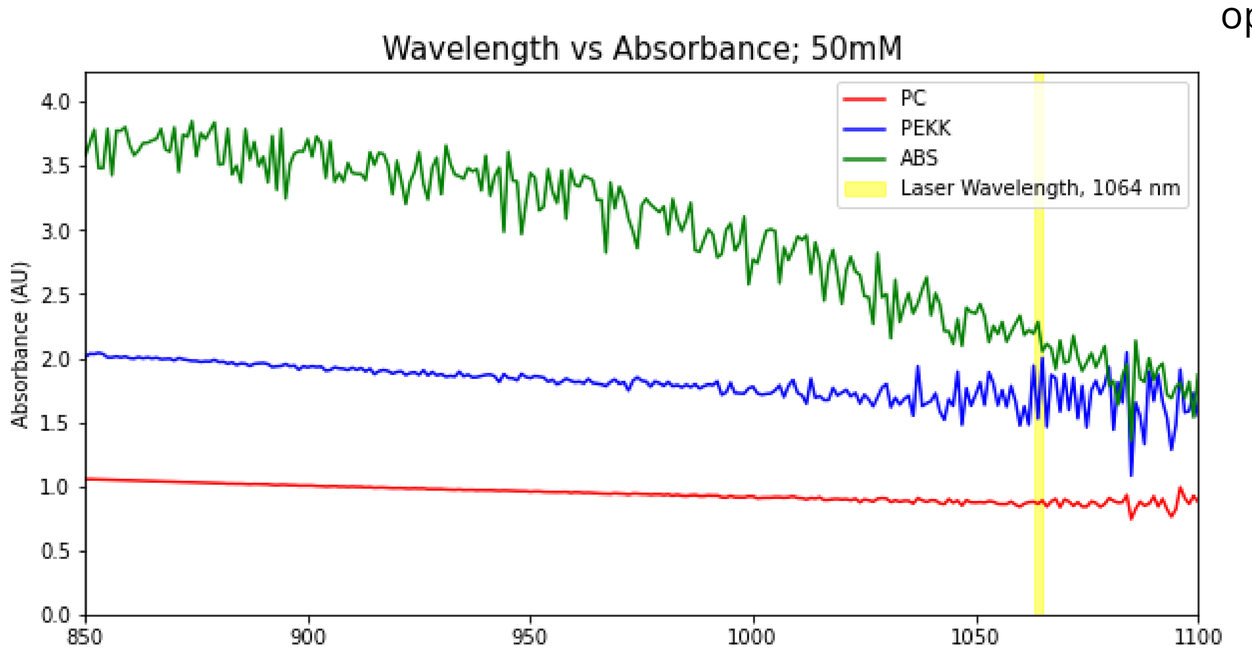

Figure 3. Profilometry plot of unablated 2.5° sample.

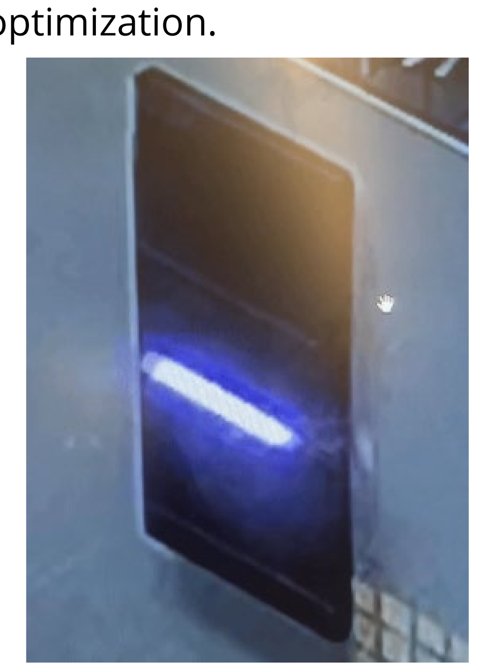

Figure 4. Laser ablation process on a 2.5° stair-stepped ABS coupon.

Results

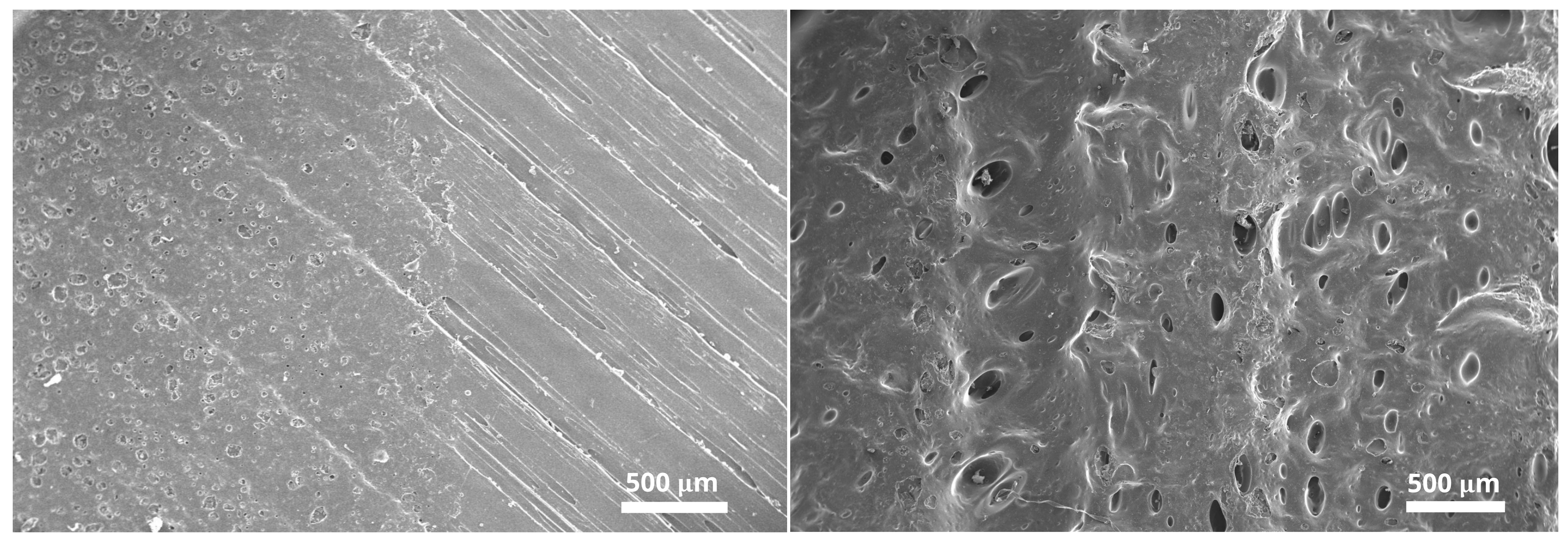

Figure 5. SEM micrographs of the ablated 0° flat coupon (left), highlighting the difference between ablated and unablated surfaces, and the 2.5° stair-stepped coupon (right).

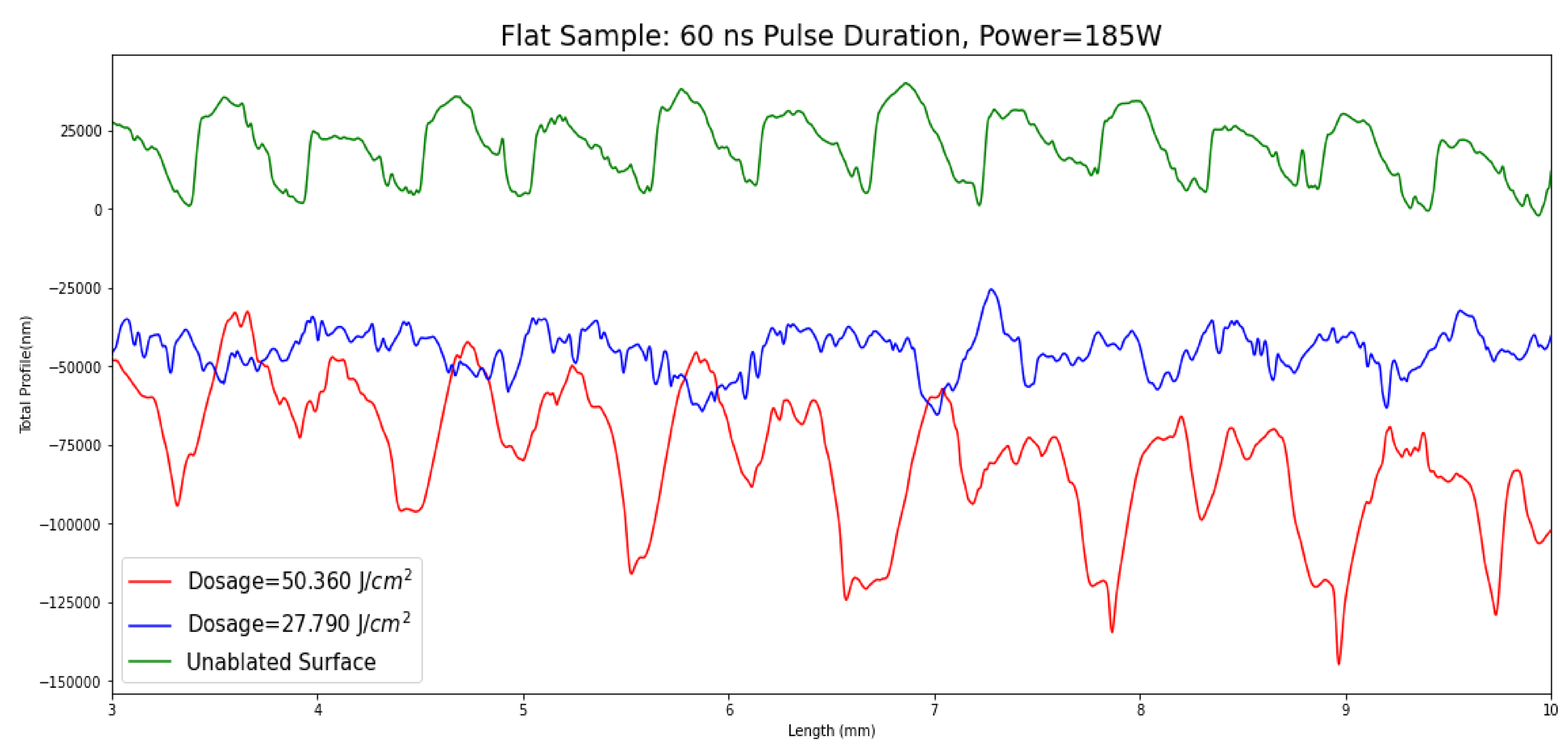

Figure 6. Profilometry plot of unablated flat sample vs low dosage and high dosage parameters on the sample.

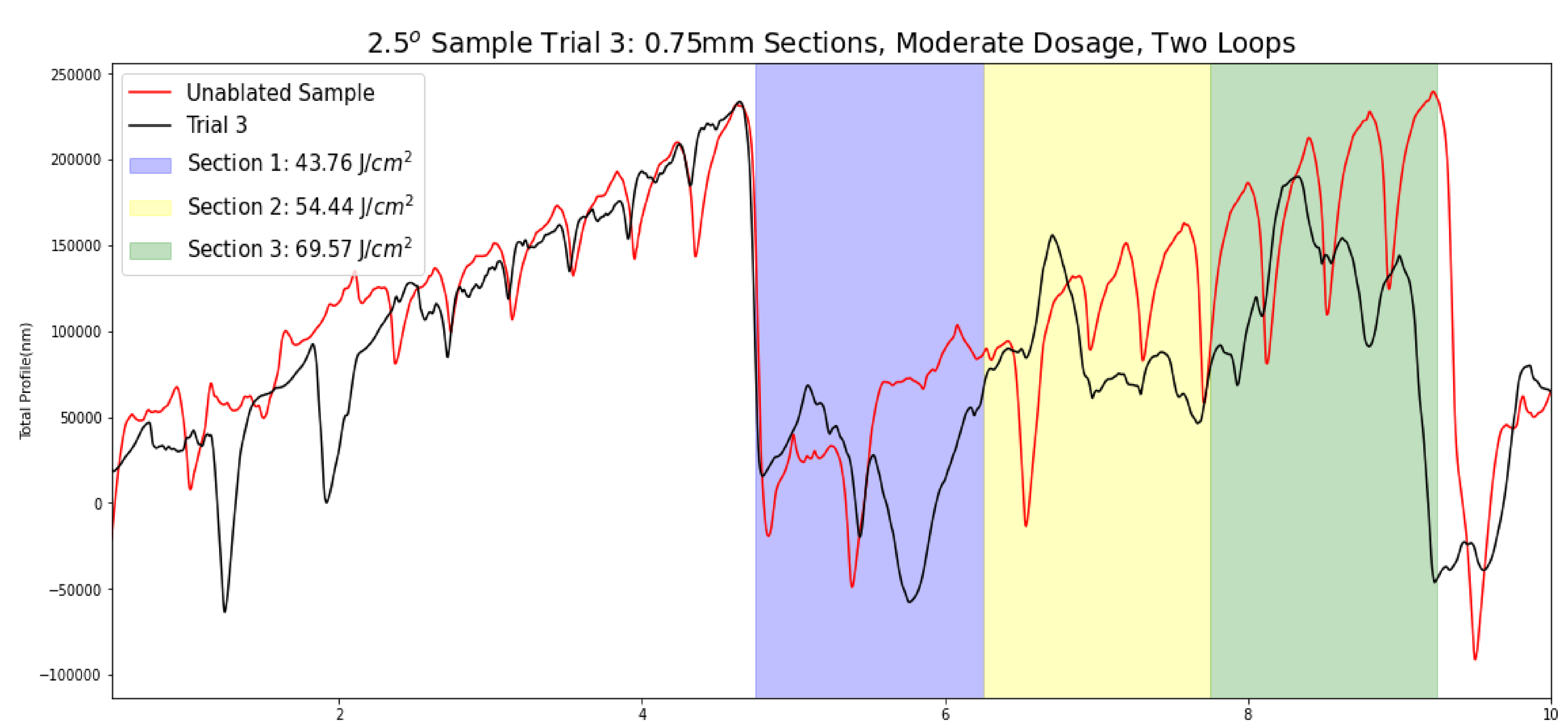

Figure 7. Profilometry plot of unablated 2.5° degree sample vs three different parameters ablated on one stair step.

Discussion

- The flat sample underwent various trials to determine optimal parameters for smoothing and penetration depth.
  - Using a profilometer, we have determined that 60 ns pulse duration with low dosage and high irradiance is best for removing material to obtain a finer surface roughness.
  - A 120 ns pulse duration with high dosage and low irradiance ablates the surface the most compared to the other parameters tested, producing a rougher surface and higher penetration depth.
- The 2.5 degree coupon had six trials ran on it to determine the best combination of parameters for evening out the stair step.
  - Trial 3 achieved the most even ablation.
  - Trial 4 successfully removed the stair-step pattern from the surface, but this resulted in increased surface roughness.
  - Trial 5 and 6 had more of an impact of removing the stair step completely and resulted in a crater effect near the end of the stair-step.

Conclusions

- For flat samples
  - Gentle dosage (27.79 J/cm^2), at a 60 ns pulse duration, is the most suitable for removing the ridges.
  - Removed an average depth of 2.066±0.258 thou of material and achieved an average surface roughness of 229.331 µin Ra.
- For large stair stepping samples
  - 120ns pulse duration, with dosages of 43.76, 54.44, and 69.57 J/cm^2.
  - The program used consisted of 3, 0.75 mm boxes with 0.375 mm of space between each.
  - The average variation in surface height was reduced by 0.160 thou.

Acknowledgements

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