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# Laser polishing of niobium for SRF applications

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### Abstract

# **Result – Optical and simulation**

Smooth interior surfaces are desired for niobium SRF cavities, now obtained by buffered chemical polish (BCP) and/or electropolish (EP). Laser polishing is a potential alternative, having advantages of speed, freedom from chemistry and inprocess inspection. Here we show that laser polishing can produce smooth topography with Power Spectral Density (PSD) measurements similar to that obtained by EP. We studied the influence of the laser power density and laser beam raster rate on the surface topography. These two factors need to be combined carefully to smooth the surface without damaging it. Computational modeling was used to simulate the surface temperature and explain the mechanism of laser polishing.

0.61 J/cm<sup>2</sup>
32 pulses overlapped
3 μm pulse displacement
Scanning speed 5.7 cm/s
melt depth 520 nm

### Simulation

- One-dimensional conduction heat transfer equation
- **Constant thermal properties**



□ No radiant heat loss or melting

Fluence within this range can polish the surface if proper pulse displacements are chosen.

0.24 J/cm<sup>2</sup>
53 pulses overlapped
1.8 μm pulse displacement
Scanning speed 3.42 cm/s
melt depth 50 nm

## Background

- □ SRF cavity inner surface should avoid sharp features to have decent performance.
- Laser polishing removes sharp features on metal surface using heat deposited by laser. Metal surface should be partially melted for polishing effects. Overheating will result in ripples and surface damage. Under heat will not smooth the surface. The amount of heat deposition can be controlled by fluence and pulse displacement. Pulse displacement means the distance between two sequential laser pulses.



 PSD gives more detailed information than RMS on sharp features on the surface.



Experiment

#### Power Oscillator (HIPPO) laser

**High Intensity Peak** 





Wavelength 1064 nm, Repetition rate 19 kHz, Pulse length 8 ns, Beam area 7.84x10<sup>-5</sup> cm<sup>2</sup>, Beam width 96 µm FWHM, Repetition rate 19 kHz.

- Disk, Diameter 49 mm, Thickness 3.2 mm.
- Polishing of niobium using laser is achievable by proper combination of fluence and pulse displacement.
   Comparison of topography and PSD analysis of laser polishing with other polishing methods shows that laser polishing smoothens sharp features in a way similar to EP.
- One dimensional heat conduction model shows that melting depth from 50nm to 520nm can result in surface polishing given proper pulse displacement.

#### Reference

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Fluence	# of pulse overlap	Pulse displace- ment	Scan speed
J/cm <sup>2</sup>	within one spot width	μm	cm/s
0.18~0.61	15~960	6.4~0.1	12.16~0.19