Laser Microfabrication for Accelerator Applications

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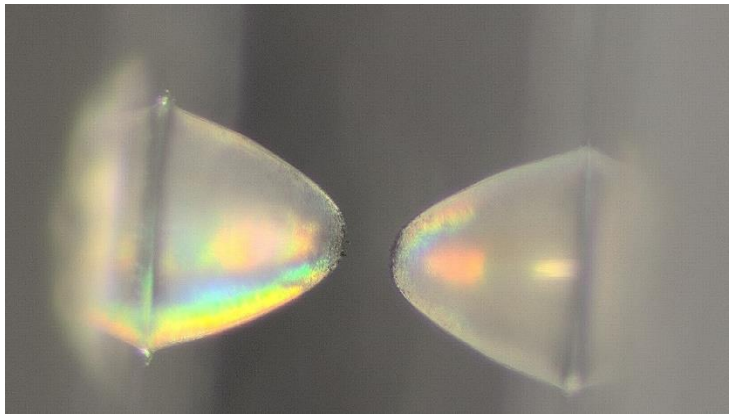
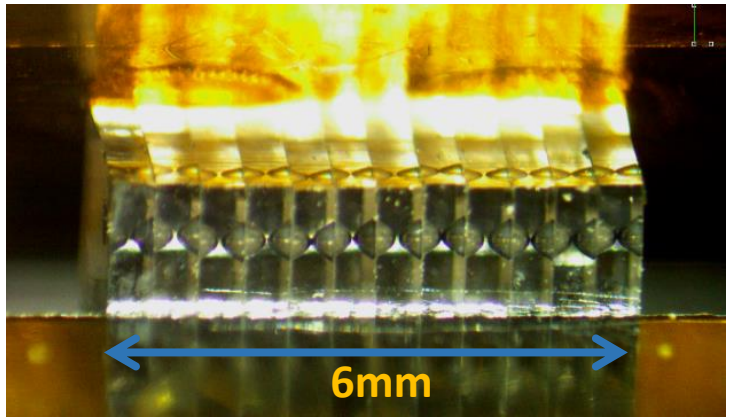
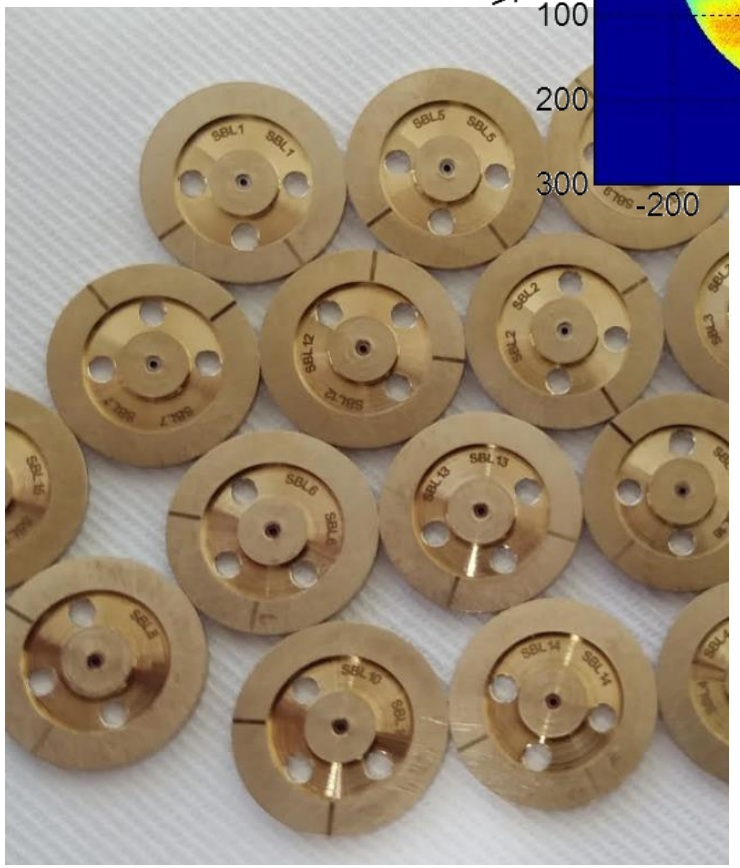
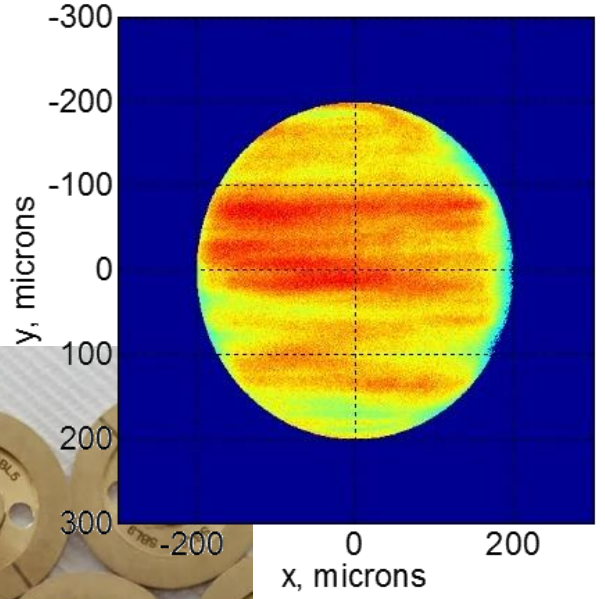
Laser microfabrication allows high precision ablation of materials at sub-mm scale. When laser pulse length is shorter than about 10 picoseconds the heat affected zone is minimized and ablation occurs without melting. Work-pieces processed in this fashion exhibit less structural damage and are expected to have a higher damage thresholds. In this paper we will review several case studies of laser-microfabricated components for accelerator and x-ray applications. Ablated materials include diamond, quartz, tungsten, copper, YAG:Ce and silicon.

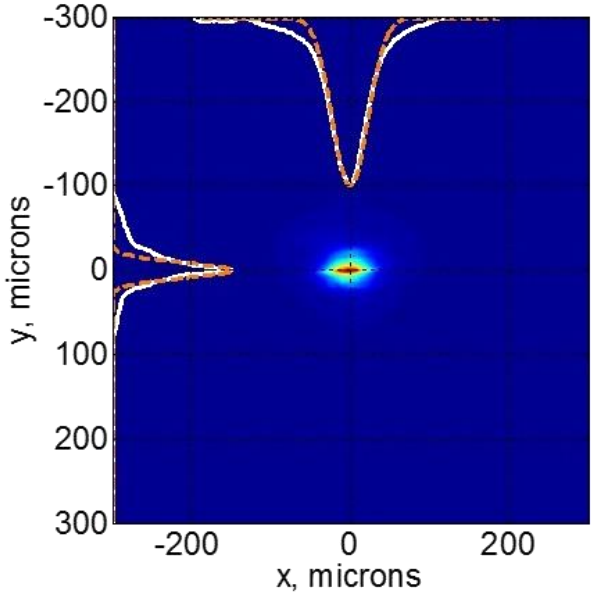
Diamond X-ray Lens







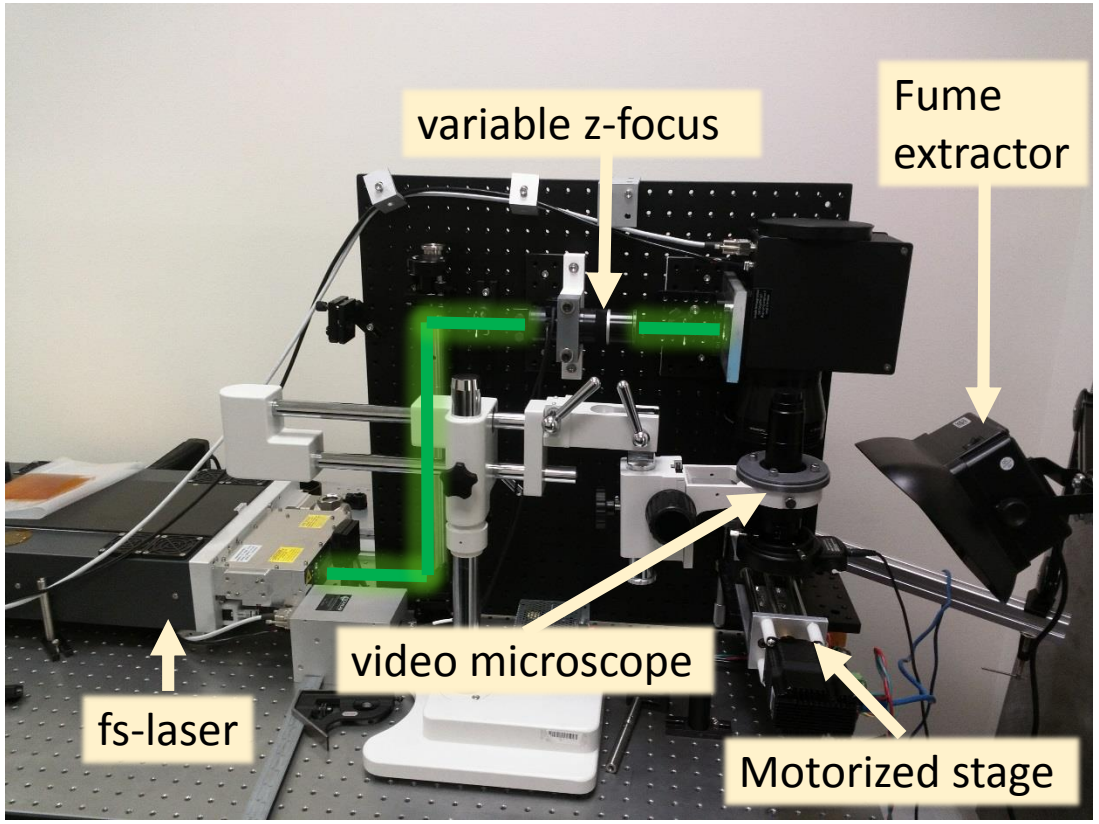


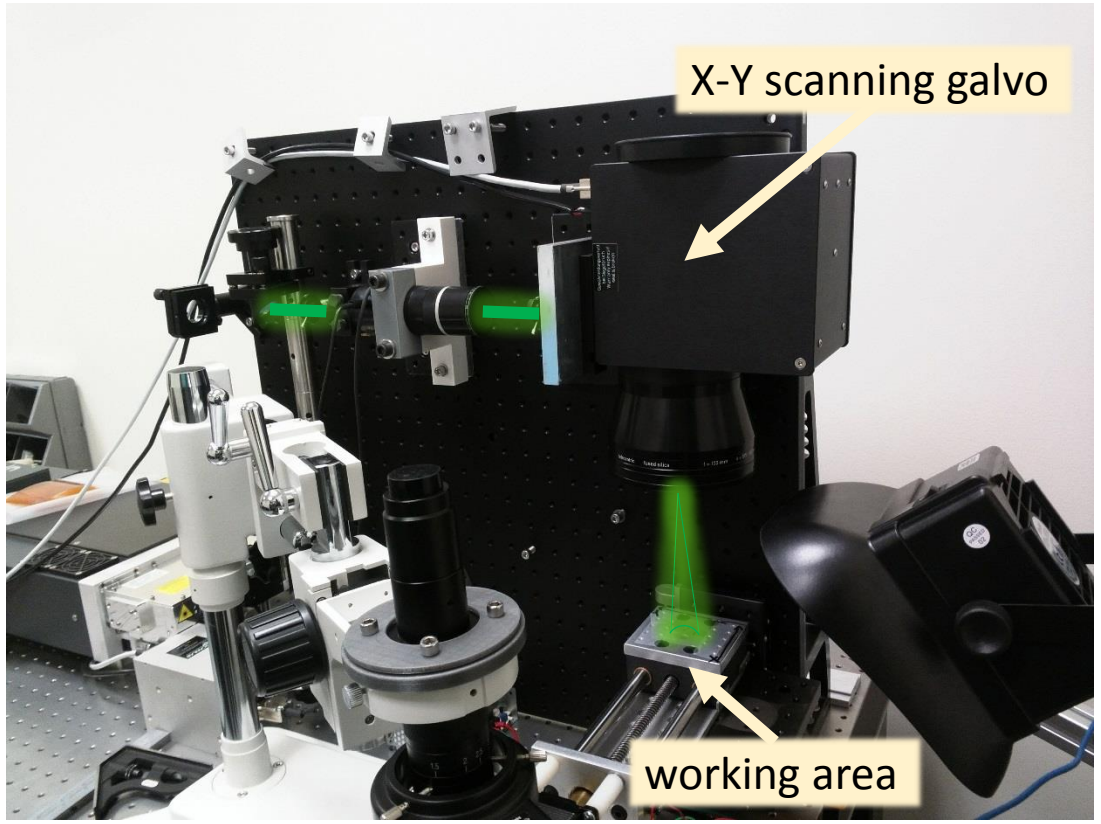


S. Antipov et. al. SRI-2015

X-ray: **11.85 keV**
ID – Lens **62m**
R = **105 um**
f = **3.36 m** (3 lens)
Pinhole = **400 um**
Focused beam:
24.5 um x 17.6 um
Gain 50-100

Femtosecond lens cutter development



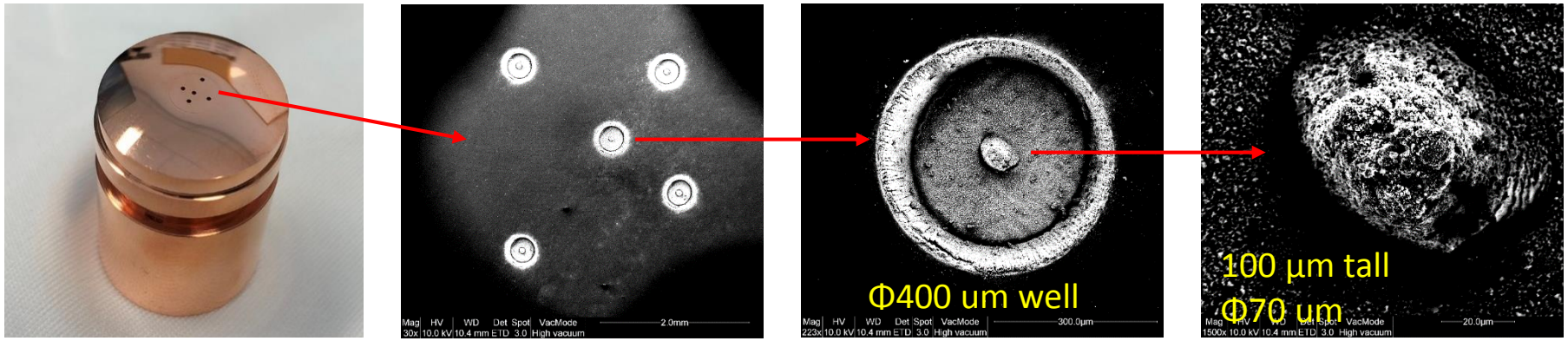


Argonne Cathode Test Stand: emission markers

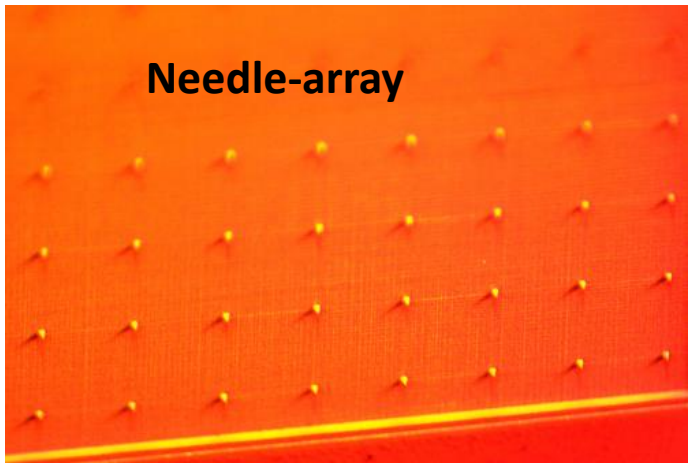
- **Cathode with pre-defined emitters**

  - Emitters created by fs-laser ablation, geometry enhancement of 3

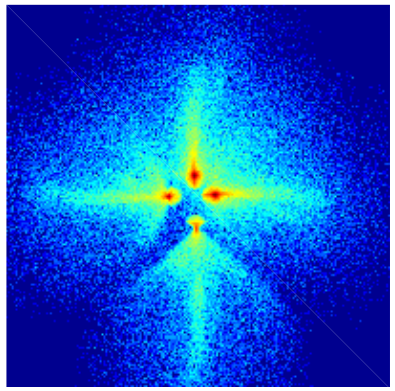
Collaboration with
J. Shao, AWA, Argonne



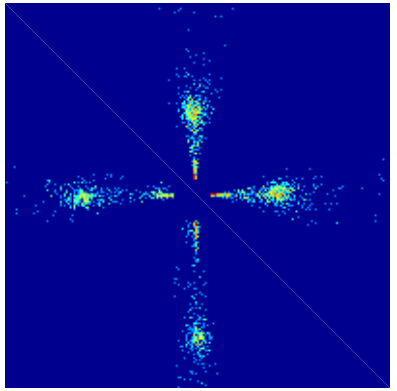
- Large emittance due to strong transverse field of the pin-in-well configuration, low imaging properties expected



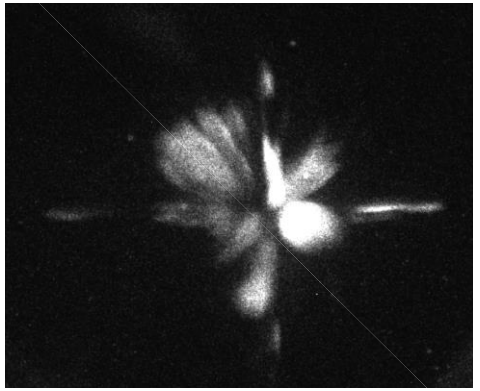
w/o collimator



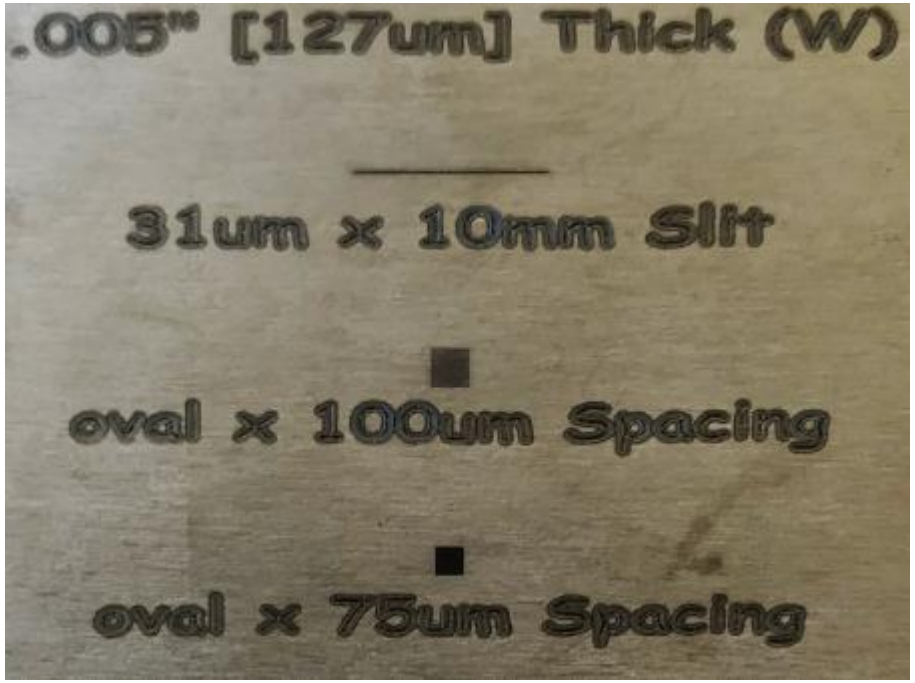
w/ Φ1 mm collimator

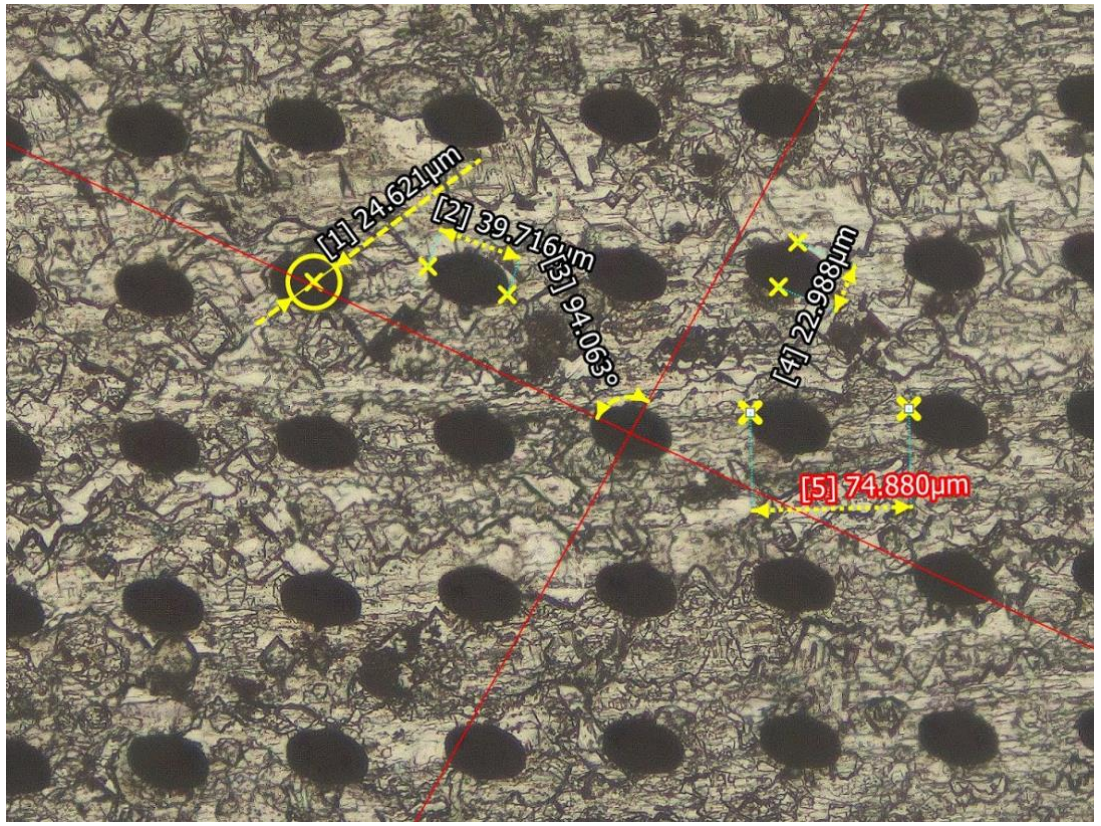


Measurement



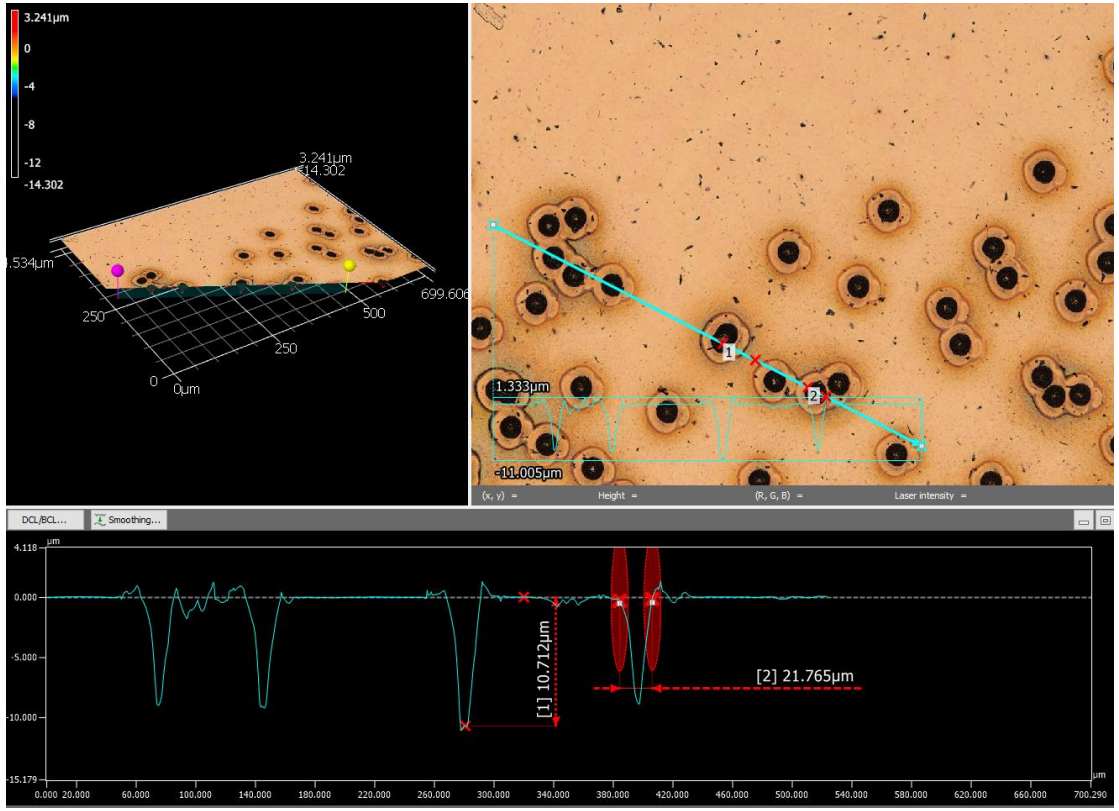
Pepper pot for emittance measurement - Tungsten



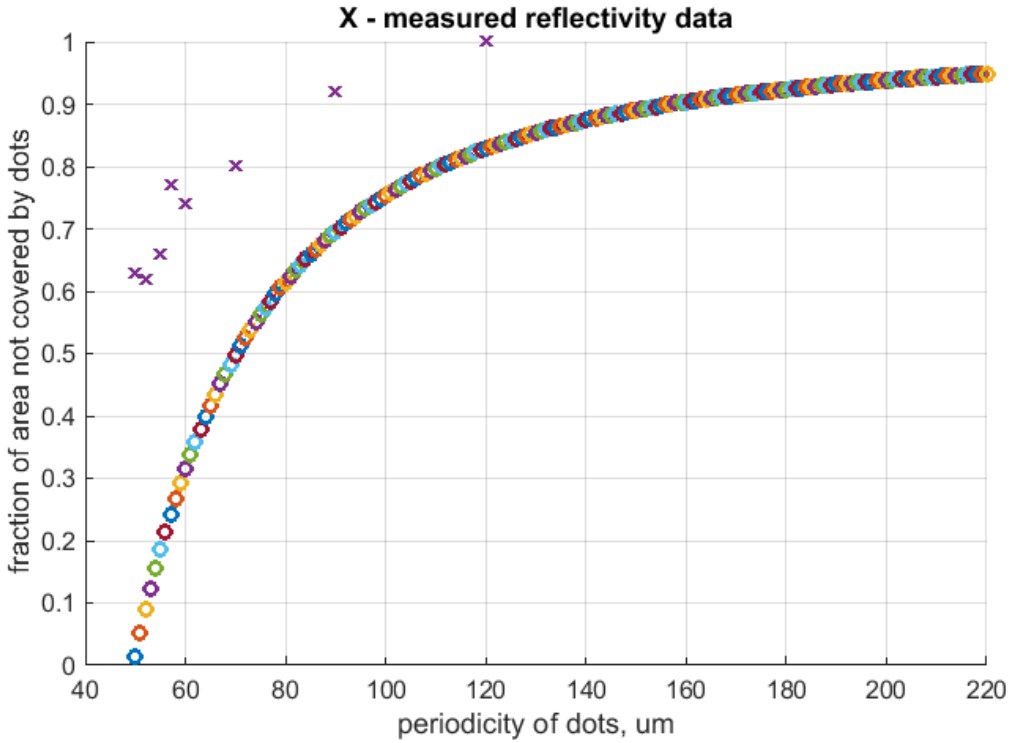


Apodization for CO2 laser mirror (COPPER)

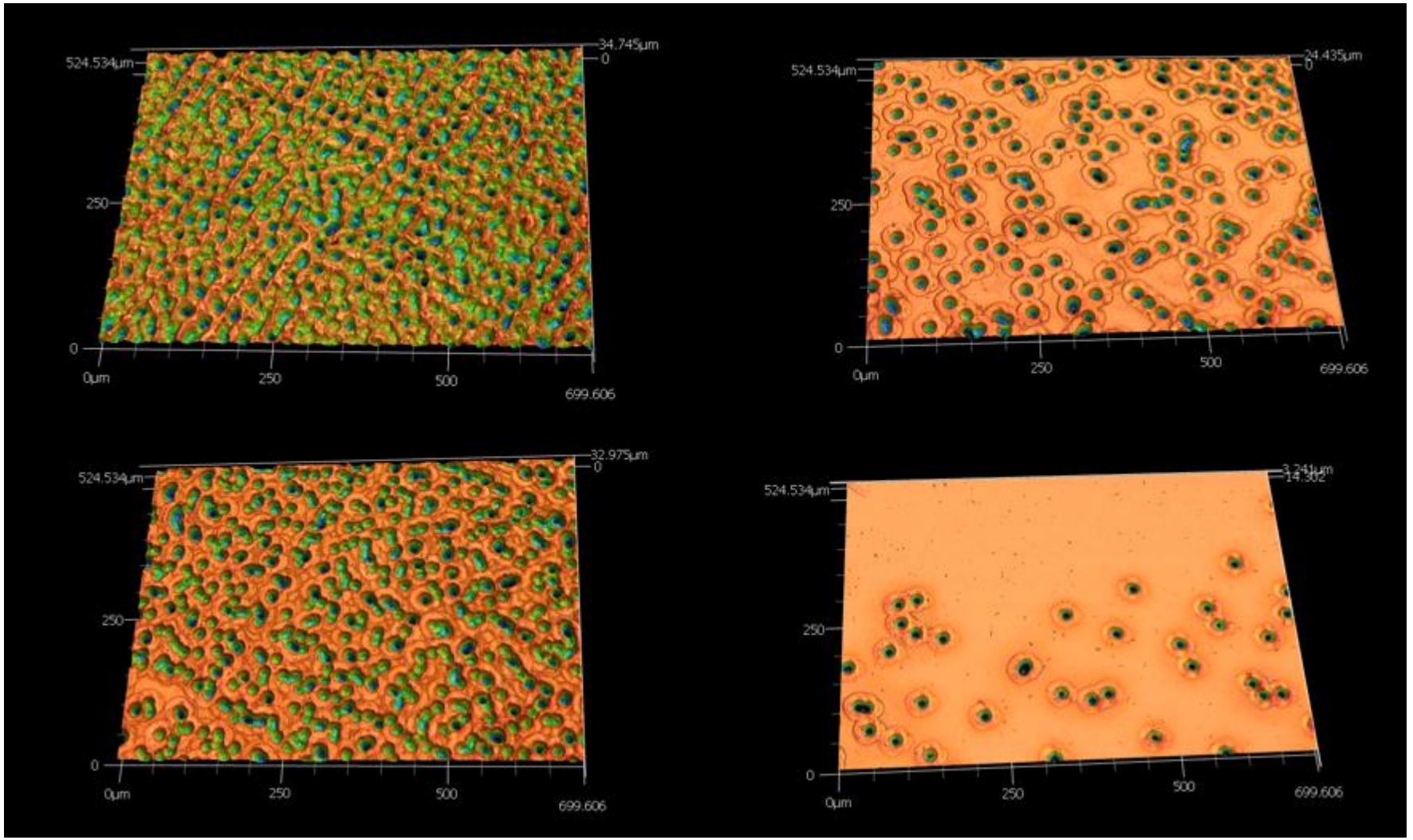
Reflection (x,y)



Collaboration with M. Polyanskiy ATF, Brookhaven

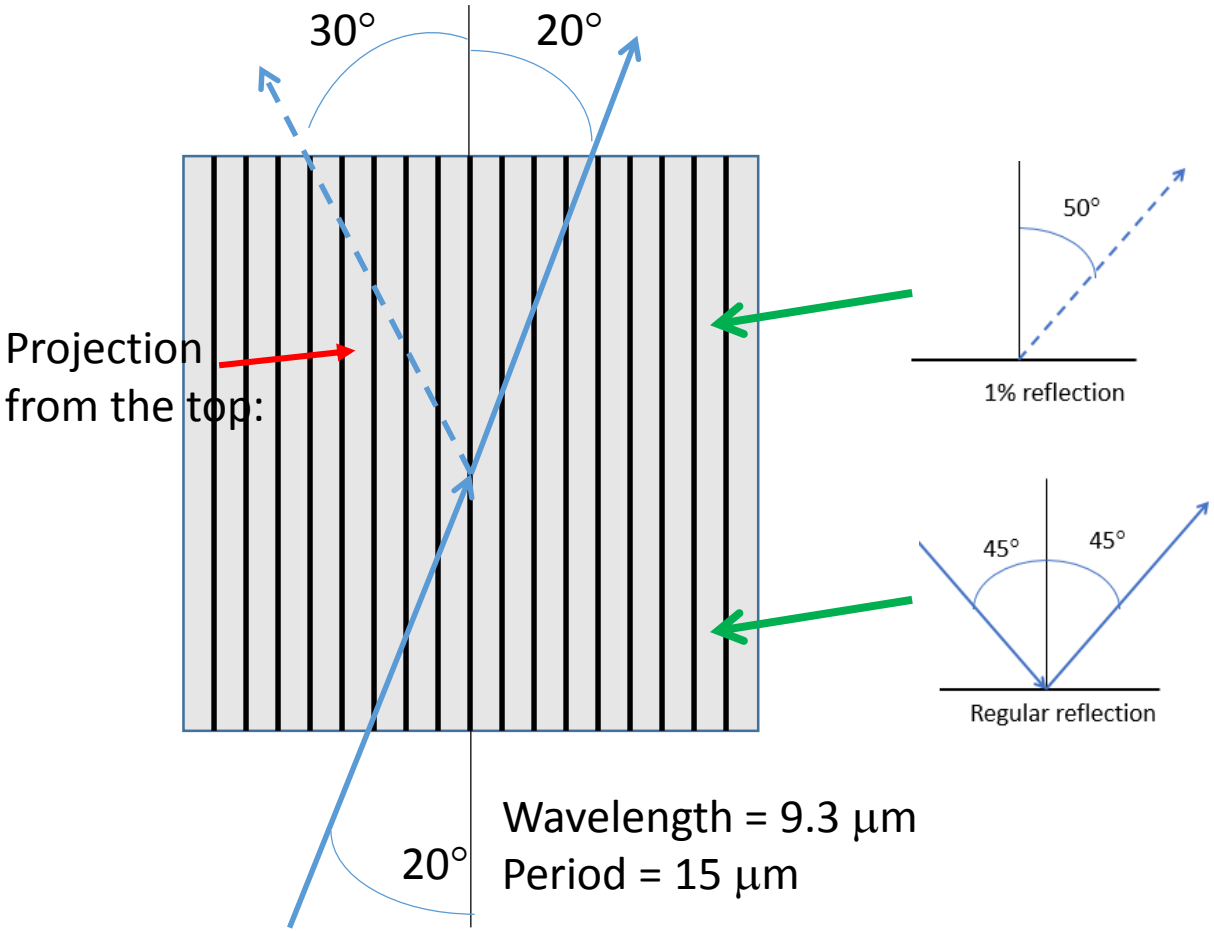


Apodization for CO2 laser mirror (COPPER)

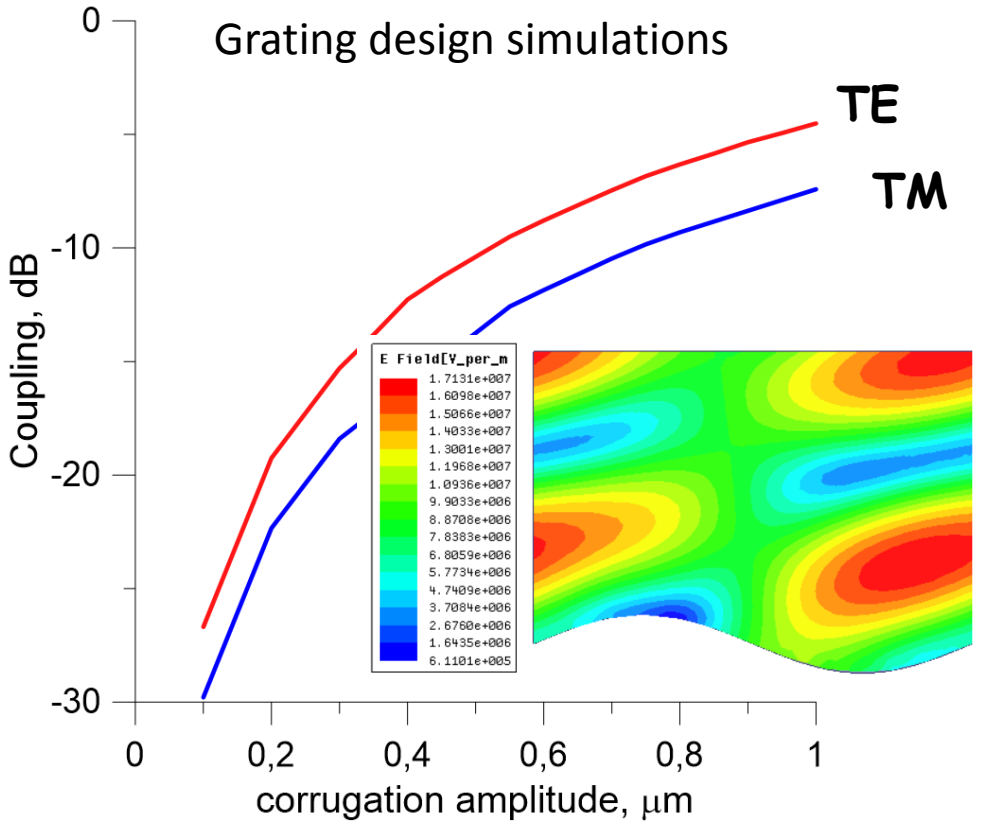


Power coupler for CO2 laser mirror (COPPER)

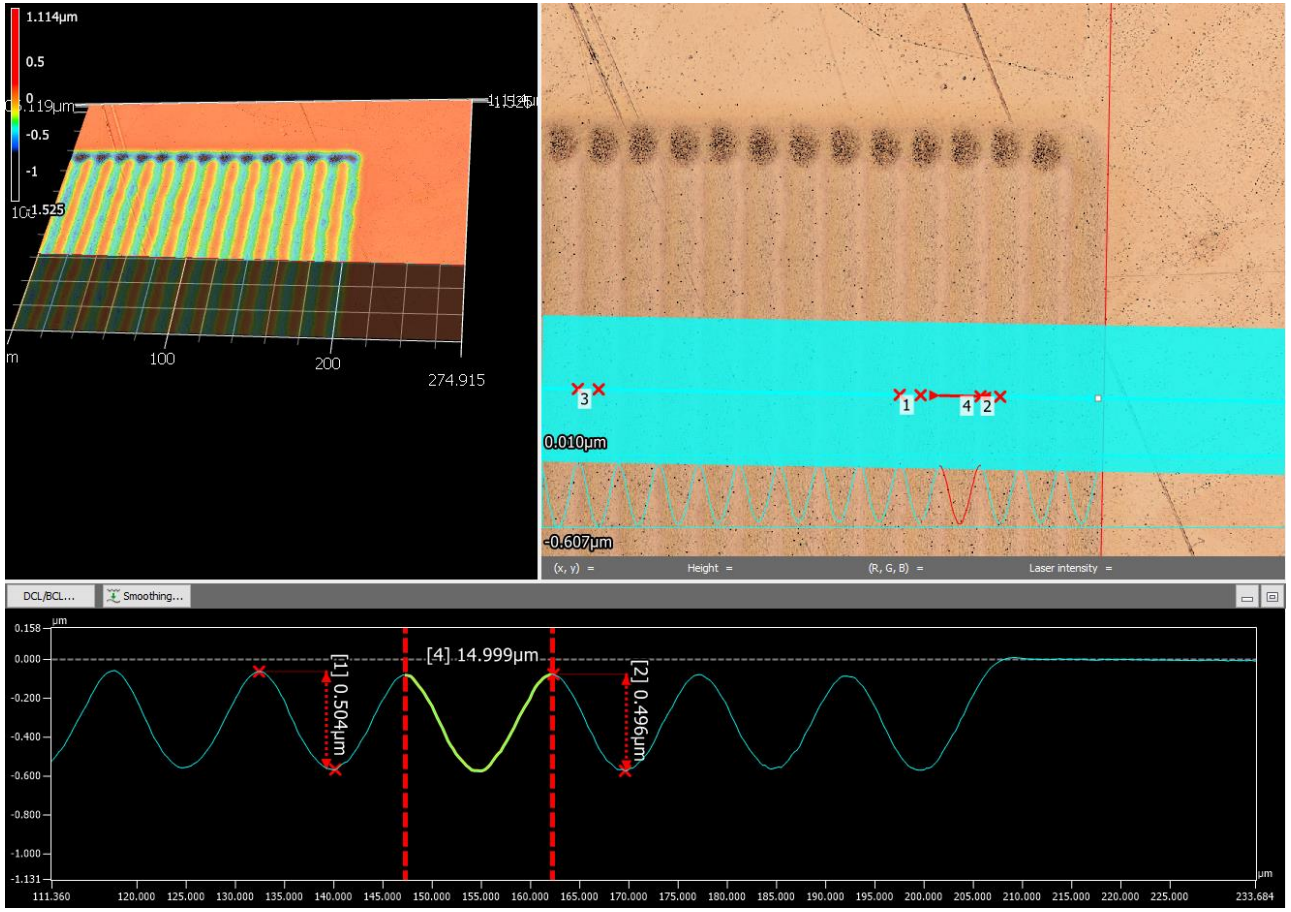
1% of power diffracts at different angle for online power monitoring



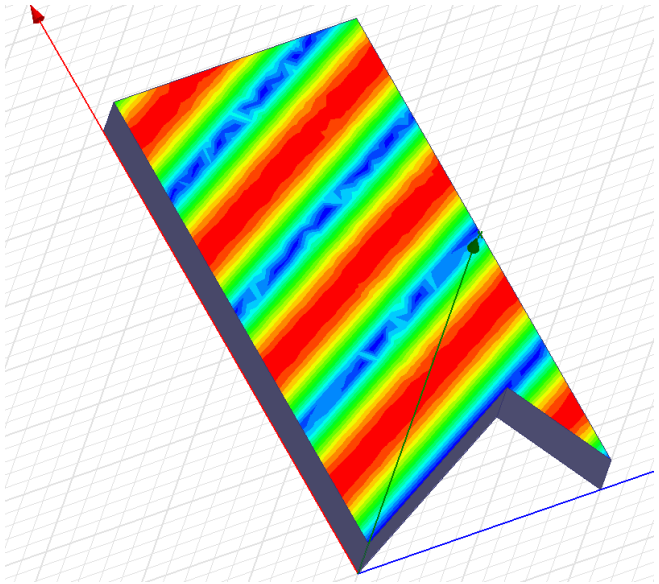
Collaboration with M. Polyanskiy ATF, Brookhaven

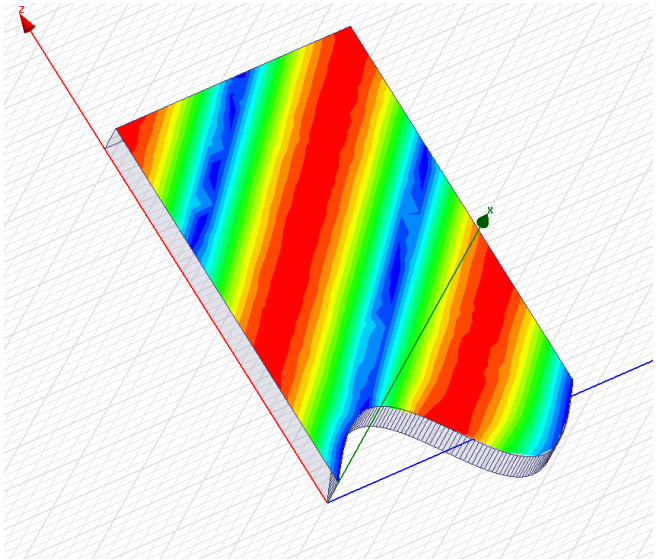


Power coupler for CO2 laser mirror (COPPER)

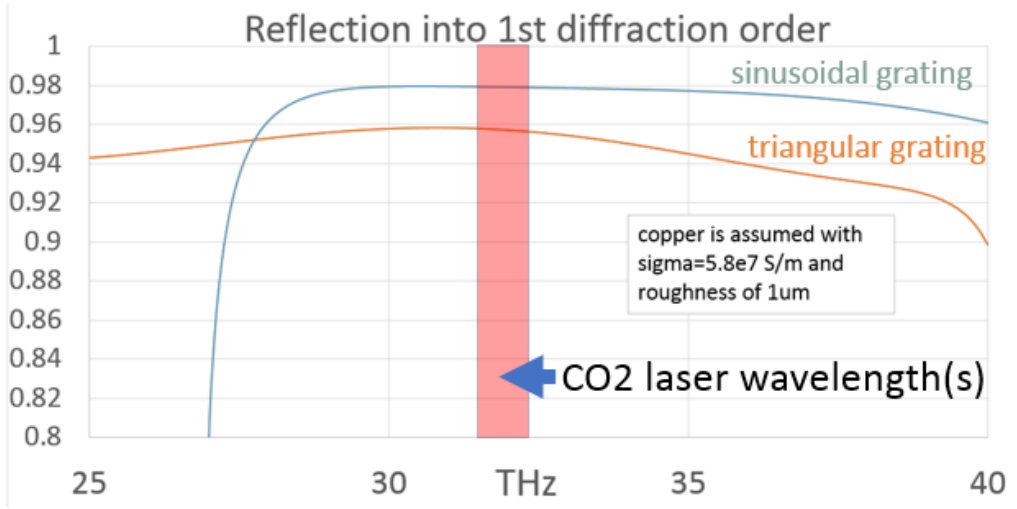


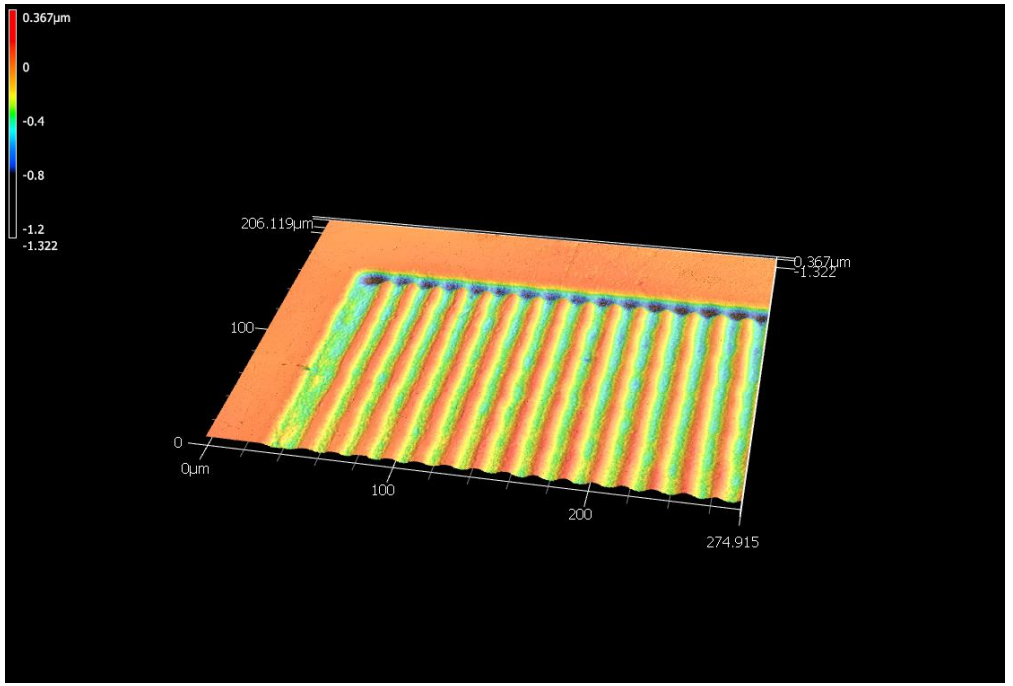
Compression gratings for CO2 laser (COPPER)





Standard echelette **Ablation optimized**





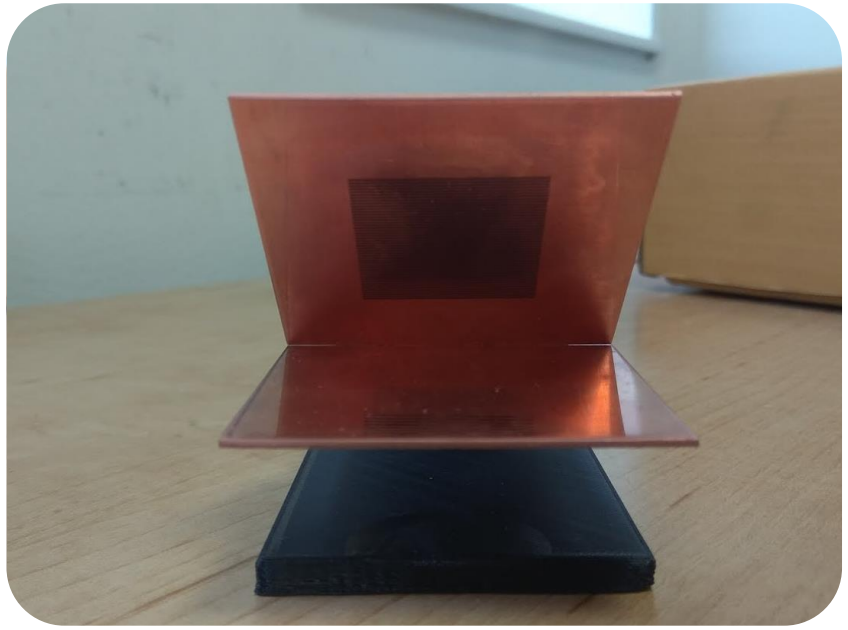
For high power operation:

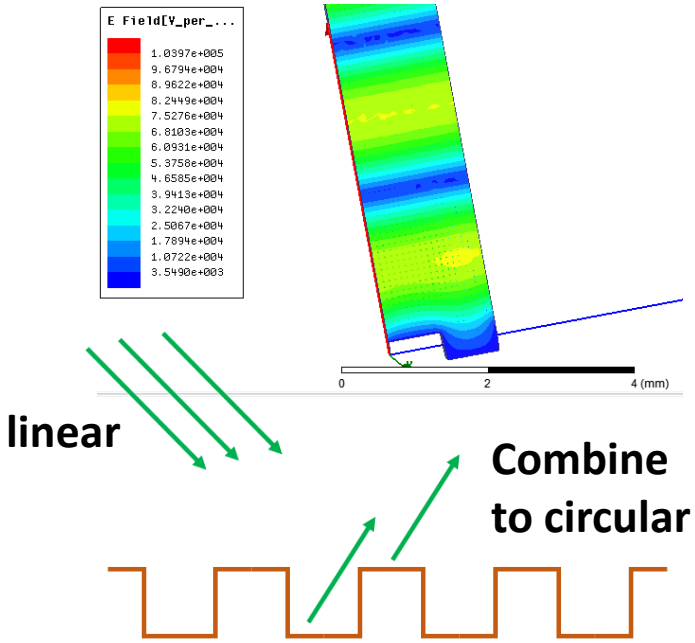
Higher efficiency

No sharp features

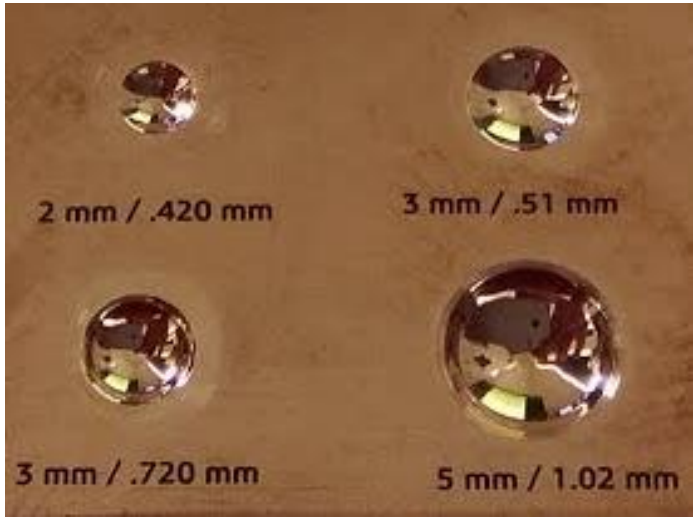
Collaboration with M. Polyanskiy ATF, Brookhaven

Other copper components for THz





Polished copper parabolic mirrors



275 GHz linear – circular polarizer

J. Wang et. al., PRSTAB 20 110401(2017)

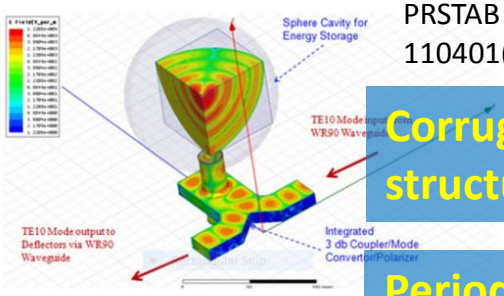
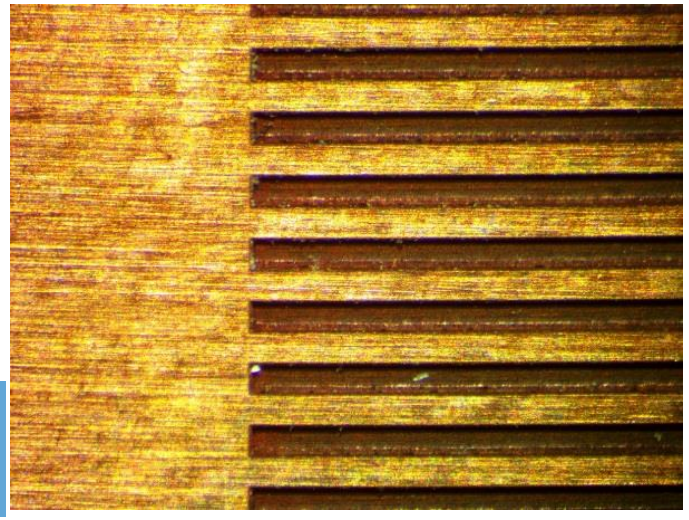


FIG. 8. The wave propagation in the SLED system.

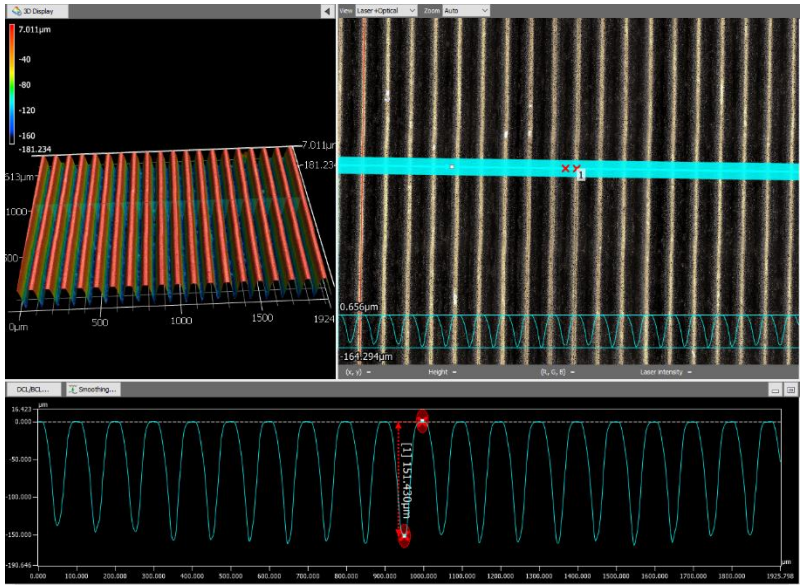
Corrugated copper structure

Periodicity = 200 um
Depth = 100 um

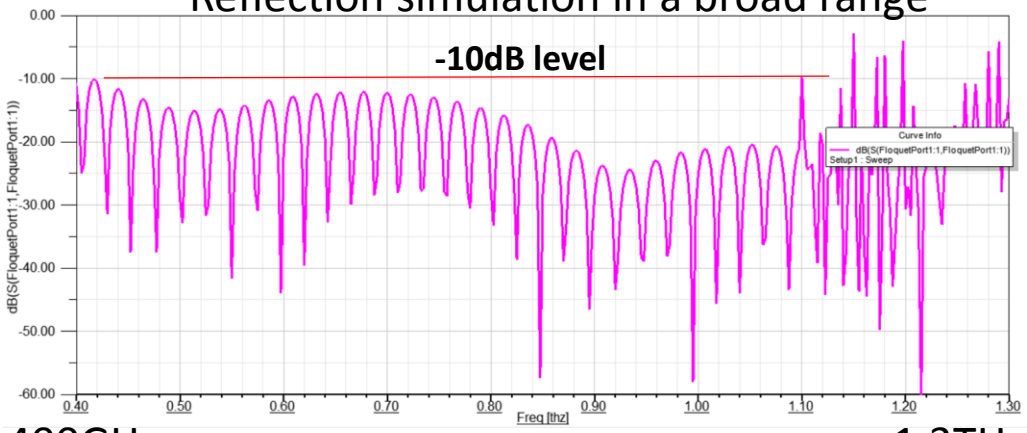


Off-axis paraboloid

Moth Eye Broadband THz Windows ~ 100um scale



Reflection simulation in a broad range



400GHz 1.3THz

- Materials: silicon, quartz
- Broadband impedance matching via periodic arrangement of sub-λ features (1D - grooves and 2D - needles)
- ~100um depth / ~100um periodicity ~ 1 THz design