Nanosecond Laser Ablation of a Copper Surface
Manuel Dillmann, Bernd Braun, Manfred Kottcke
Technische Hochschule Nürnberg, Department of Physics, Mathematics and Humanities,
Kesslerplatz 12, 90469 Nuremberg, Germany;

Introduction:
This work investigates the ablation of a copper surface caused by the irradiation of a 220 ns laser pulse. Our focus is on the heat transport within the copper and takes the proceeding vaporization of surface substance into account. Our model ignores plasma dynamics and simulates the energy deposition using a surface heat source. The underlying absorption coefficient is made temperature dependent, for the considerable coupling of the laser irradiation with near surface metal vapor.

Parameter study:
Variation of pulse energy and spot size

<table>
<thead>
<tr>
<th>Laser Parameter</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse energy</td>
<td>0.286</td>
<td>mJ</td>
</tr>
<tr>
<td>Peak intensity</td>
<td>3.8 - 10^{14}</td>
<td>W/m²</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>220</td>
<td>ns</td>
</tr>
<tr>
<td>Spot size</td>
<td>27.5</td>
<td>μm</td>
</tr>
</tbody>
</table>

Conclusions and next steps:
- Simulation delivers time dependent surface temperature and ablation
- Reasonable values for ablated volume
- Correlation of ablation with pulse energy and with spot size investigated
- Good agreement with experimental data
- Influence of pulse shape further to be investigated

Experimental Data

- Laser material processing:
  - Commercial ns fiber Laser; λ=1.064 μm
  - Commercial XY Scanning unit
  - F-Theta objective lens with 80 mm focal length
- Characterization:
  - Optical microscopy
  - Scanning electron microscopy
  - 3d visualization retrieved by a commercial analyzing software, based on stereoscopic SEM images

Simulation and Results

Figure 1. Time dependent heat transfer and ablation

Figure 2. Ablated volume (exp. data blue line, simulated red line)

Figure 3. Experimental determination of ablated material

Excerpt from the Proceedings of the 2016 COMSOL Conference in Munich