

# Nanosecond Laser Ablation of a Copper Surface

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## 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

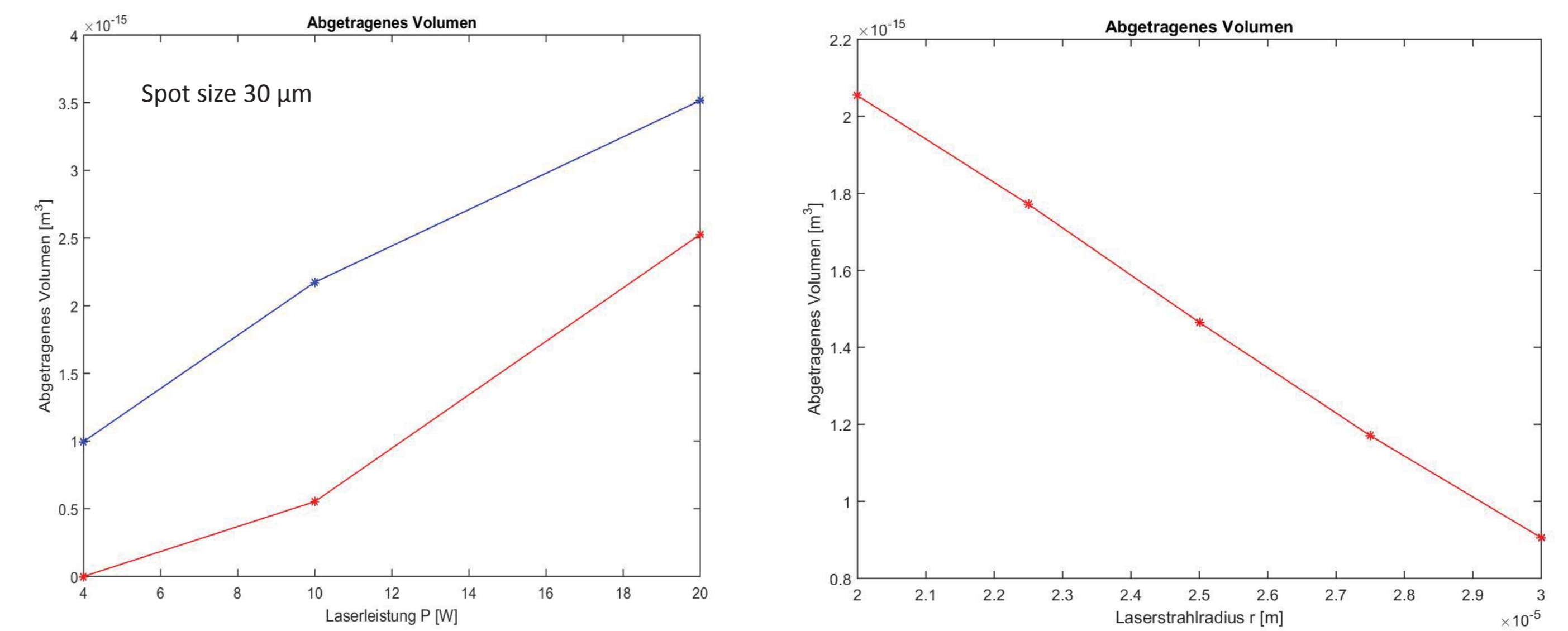


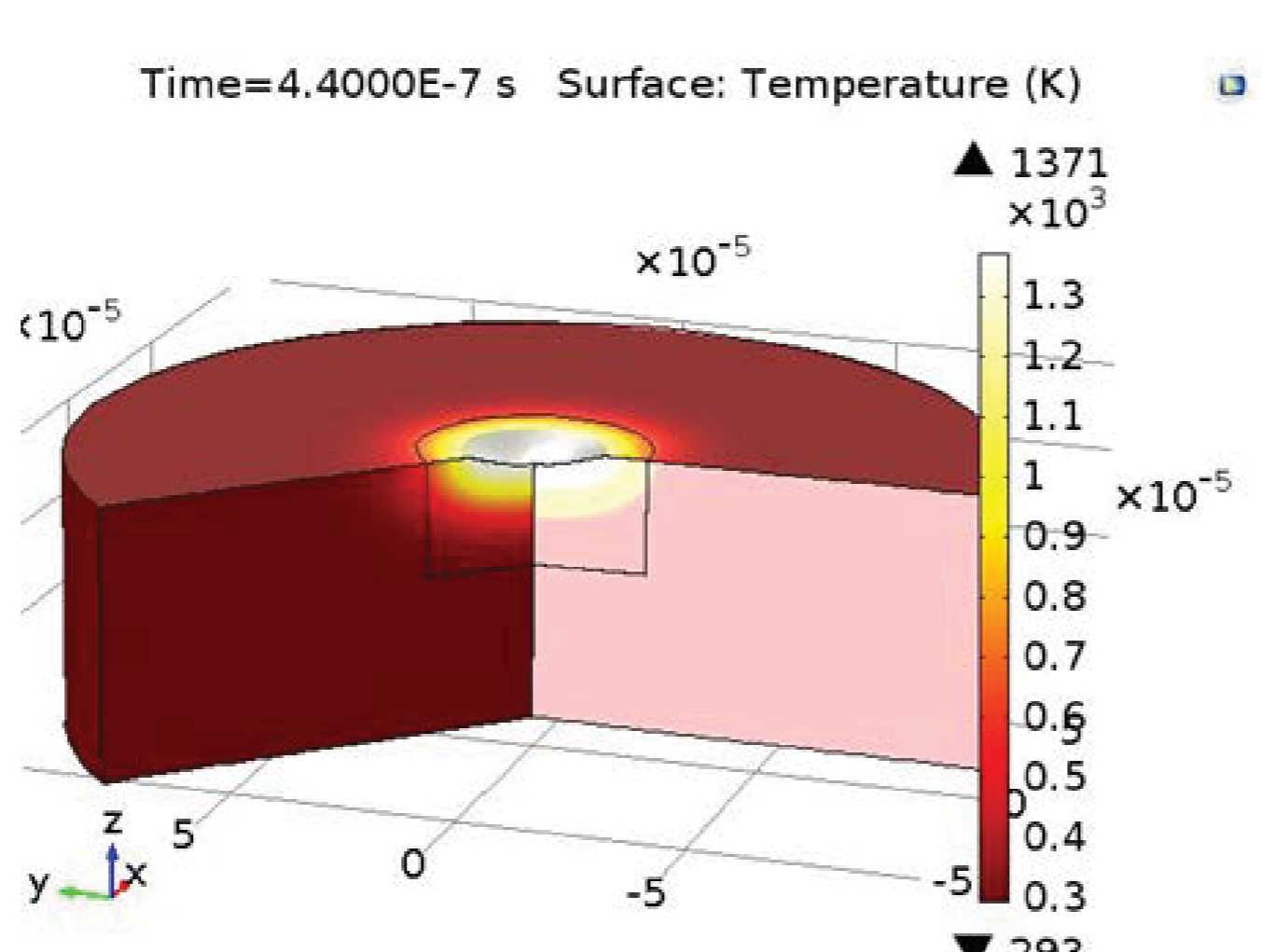
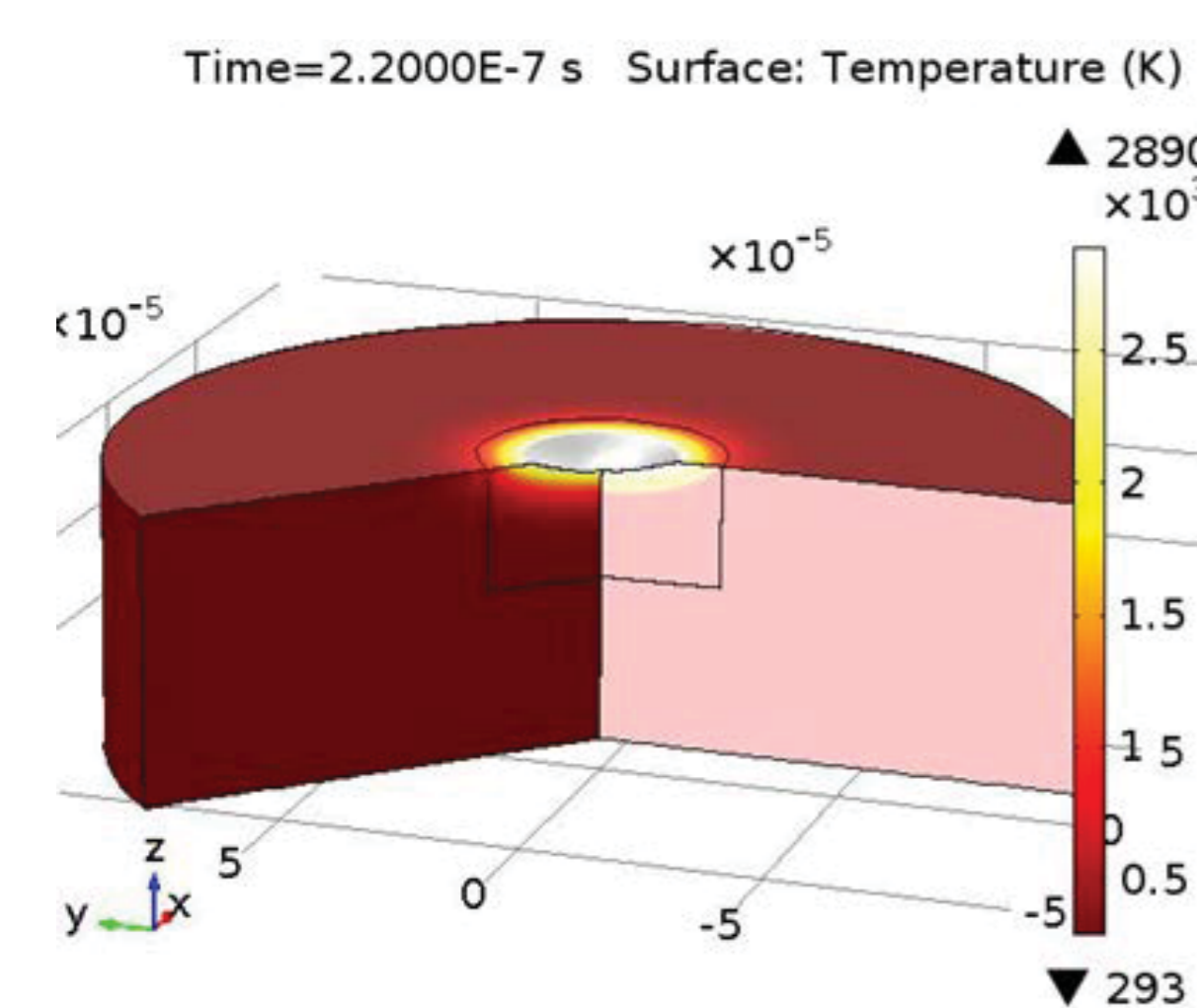
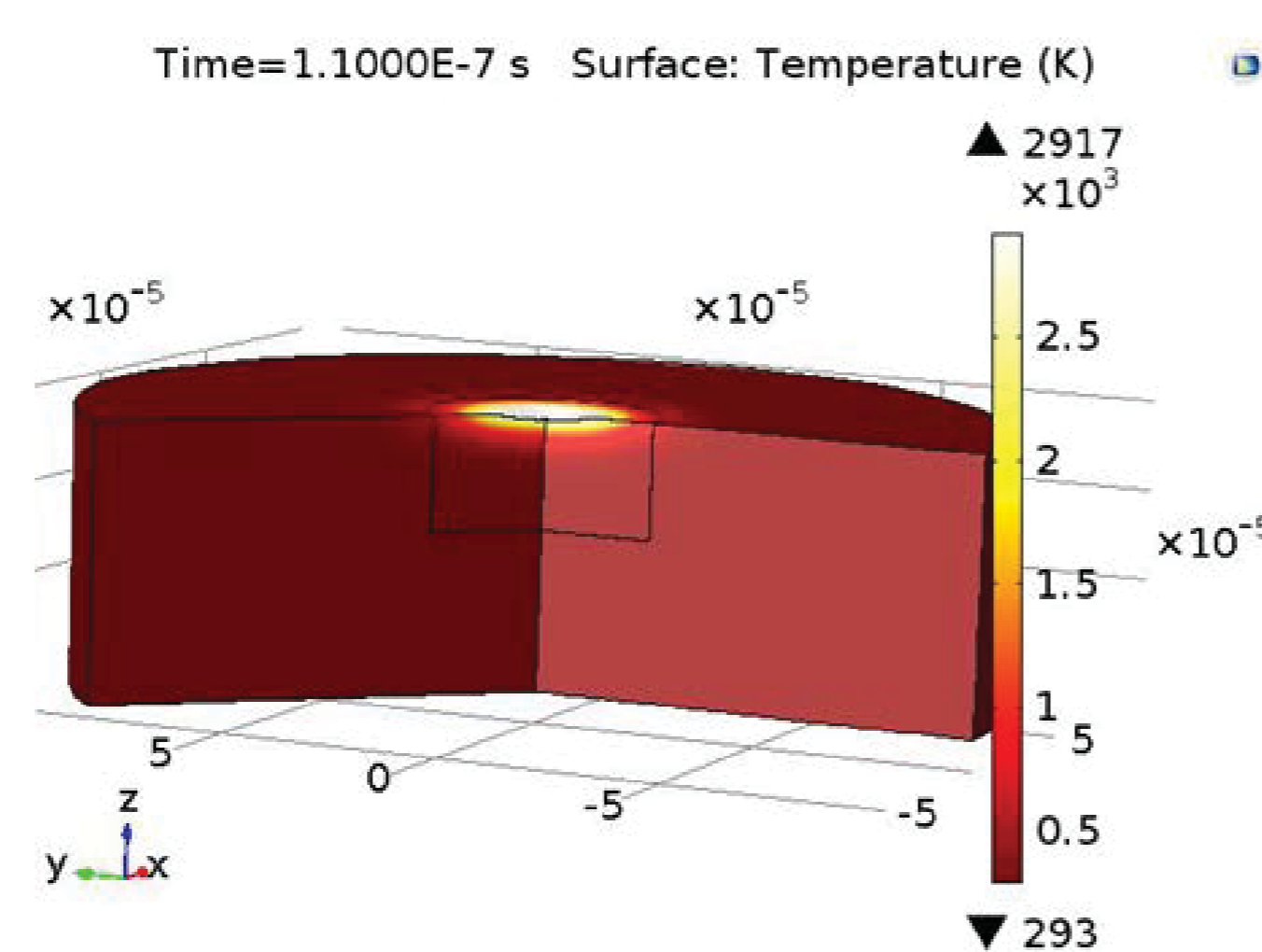
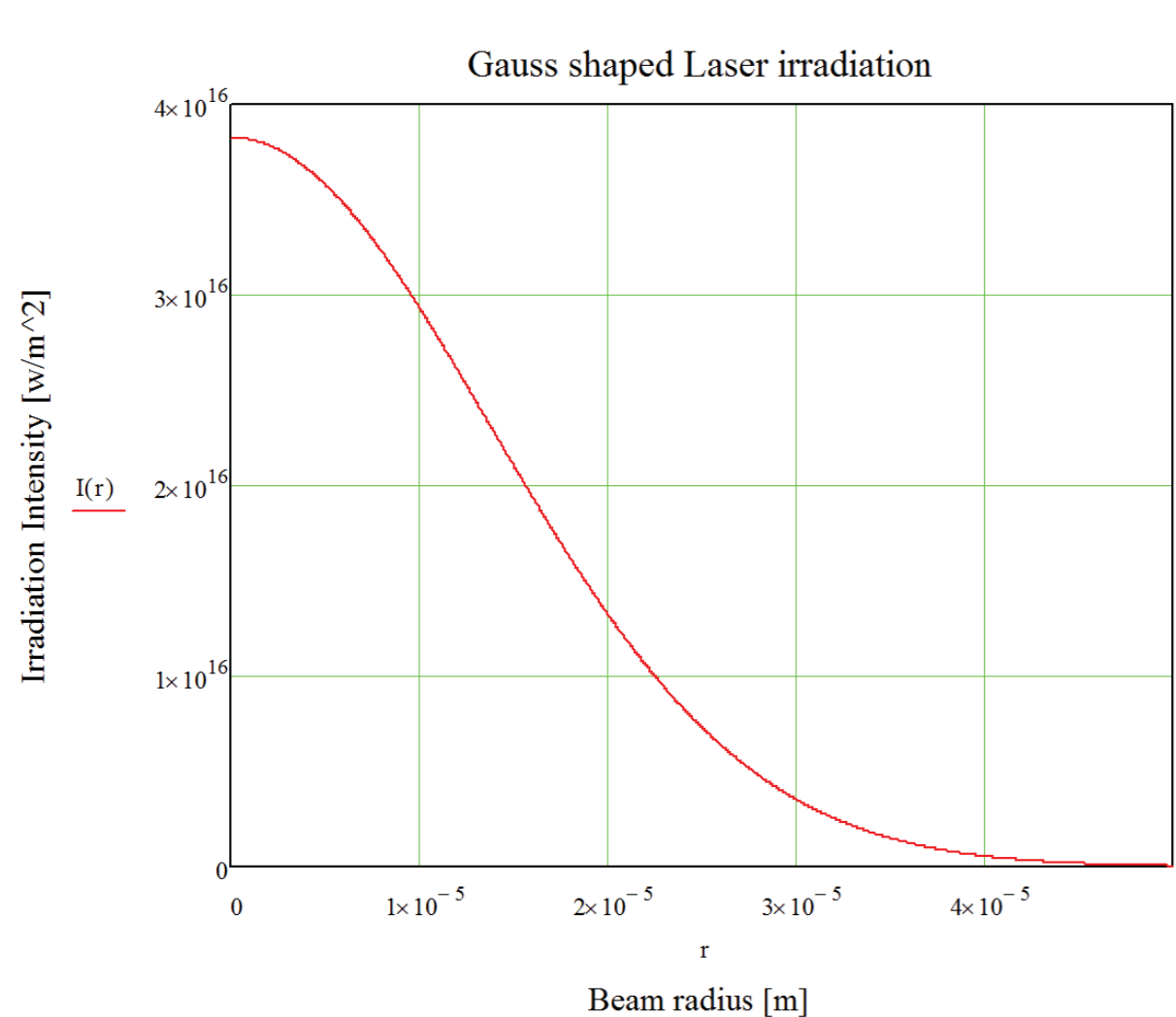
Figure 2. Ablated volume (exp. data blue line, simulated red line)

## Simulation and Results

Table 1. Beam parameters

Laser Parameter	Value	Units
Pulse energy	0.286	mJ
Peak intensity	$3.8 \cdot 10^{16}$	$W/m^2$
Pulse duration	220	ns
Spot size	27.5	$\mu m$

- Laser pulse considered to have Gauss profile; rectangular time shape assumed
- Absorption coefficient  $\alpha=0.1, 0.2, 0.4$  resp. for solid, melted and vaporized surface, experimentally validated
- Simulation of heat transfer in a cylindrical copper bulk, using a FEM mesh with deforming geometry
- Time dependent study investigates heat transfer, ablation and after pulse cooling
- Parameter dependent studies varied spot size and pulse energy
- Theory - Experiment comparison with real world laser ablation



## Experimental Data

- Laser material processing:
  - Commercial ns fiber Laser;  $\lambda=1.064 \mu m$
  - 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

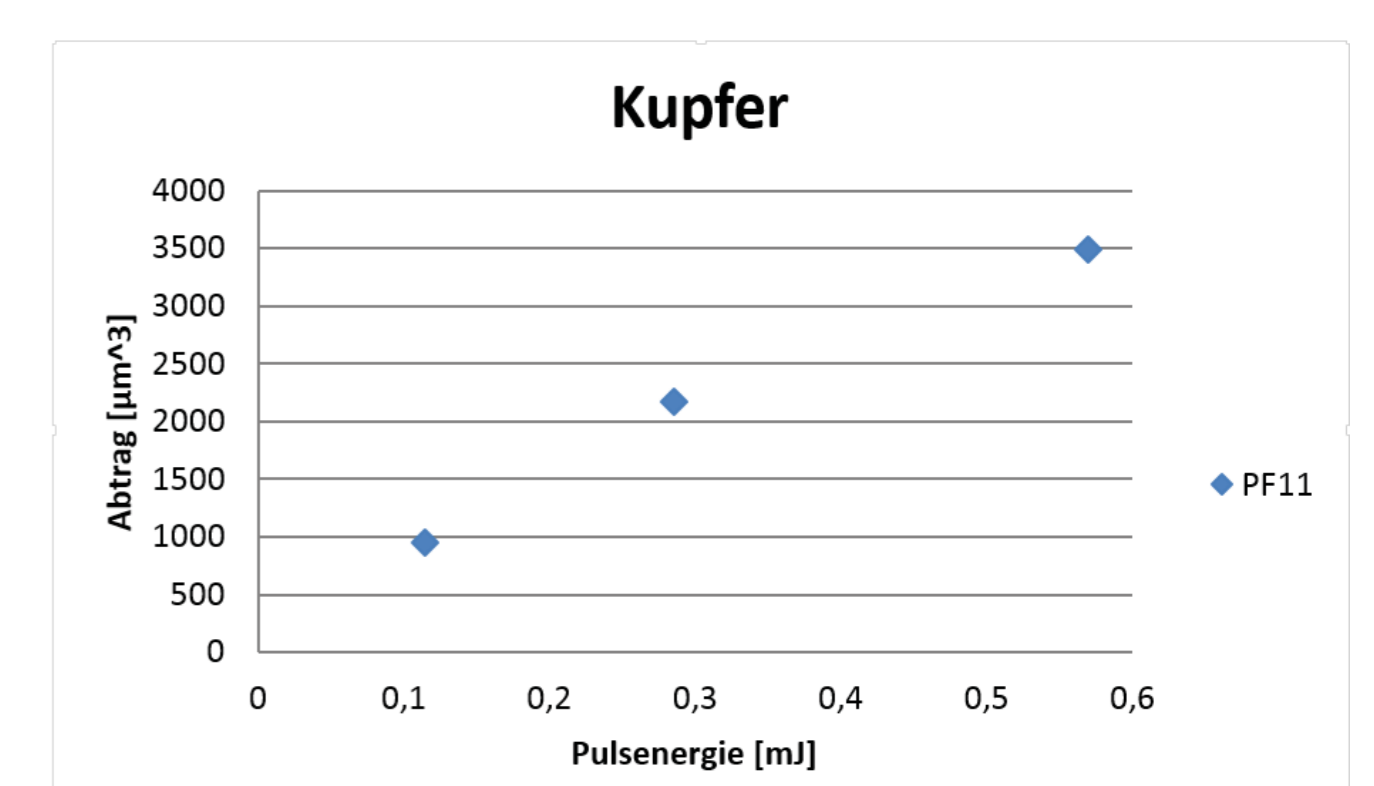
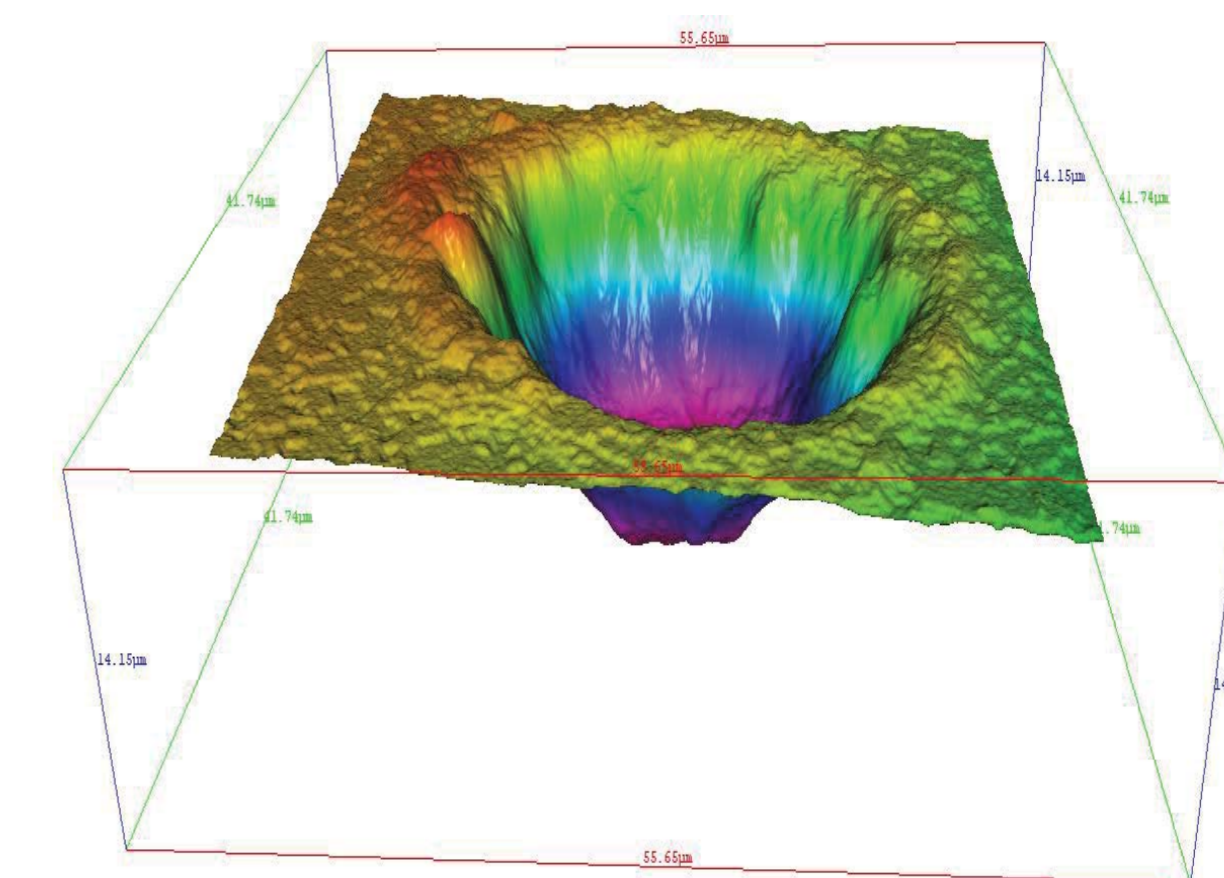
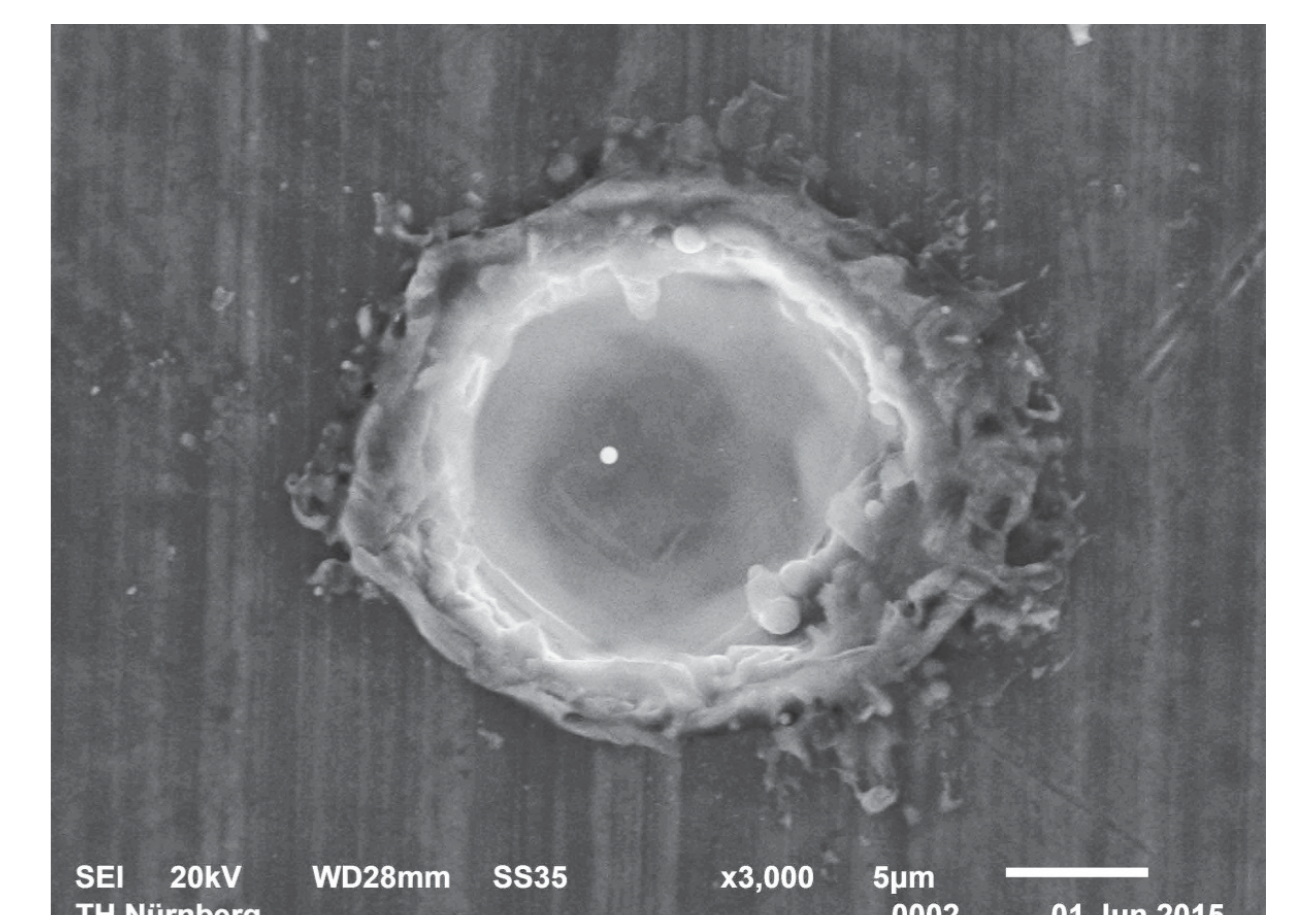
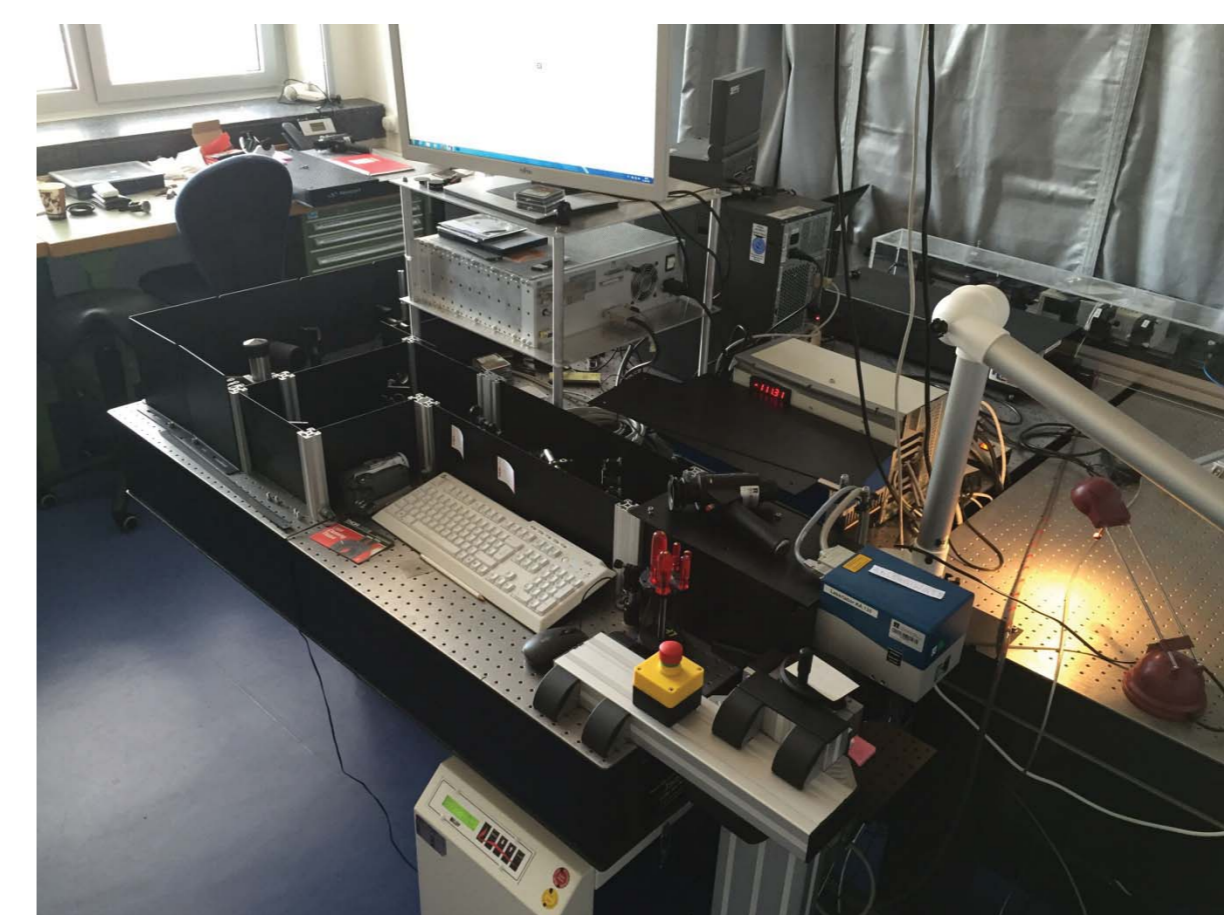


Figure 3 Experimental determination of ablated material

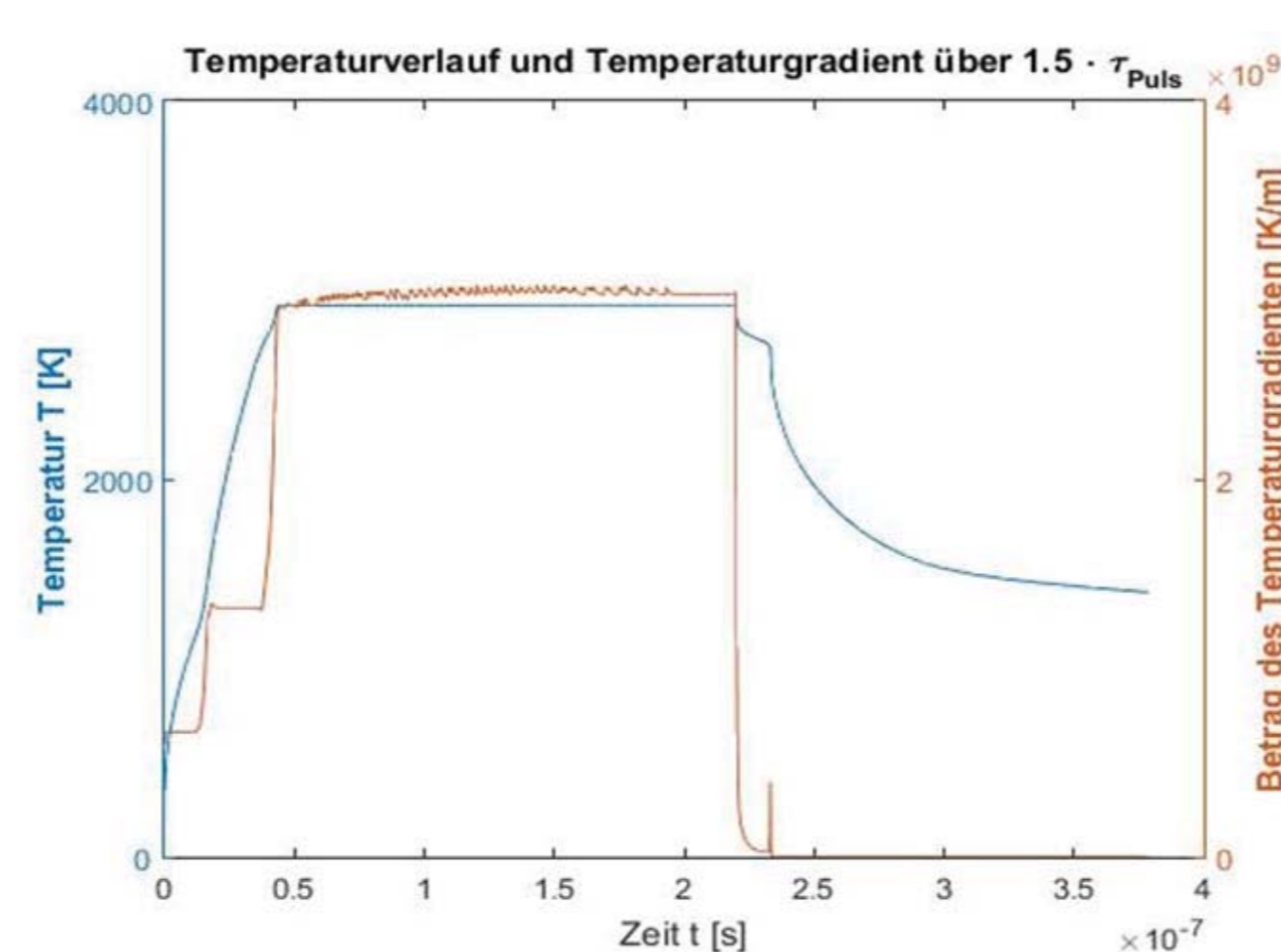
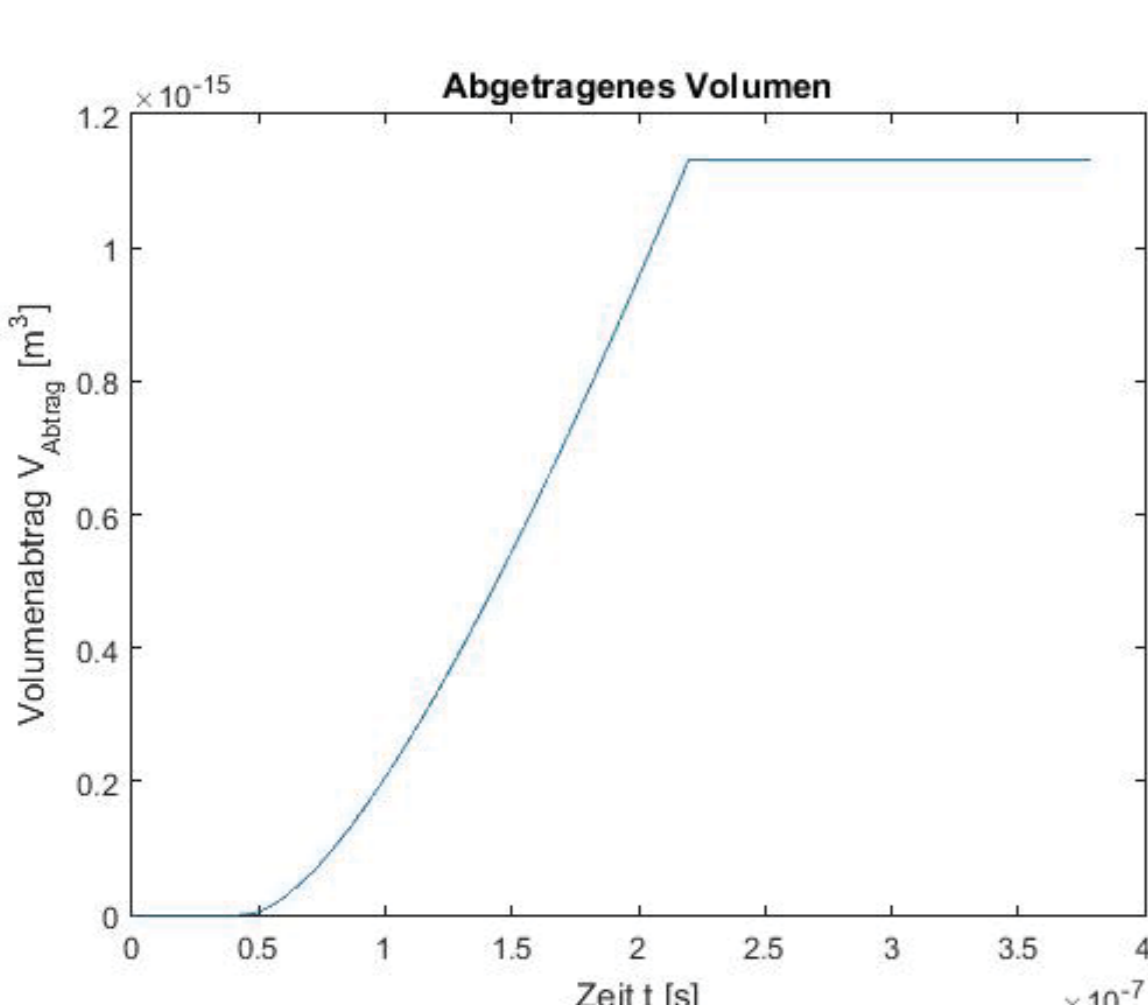


Figure 1. Time dependent heat transfer and ablation

## 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