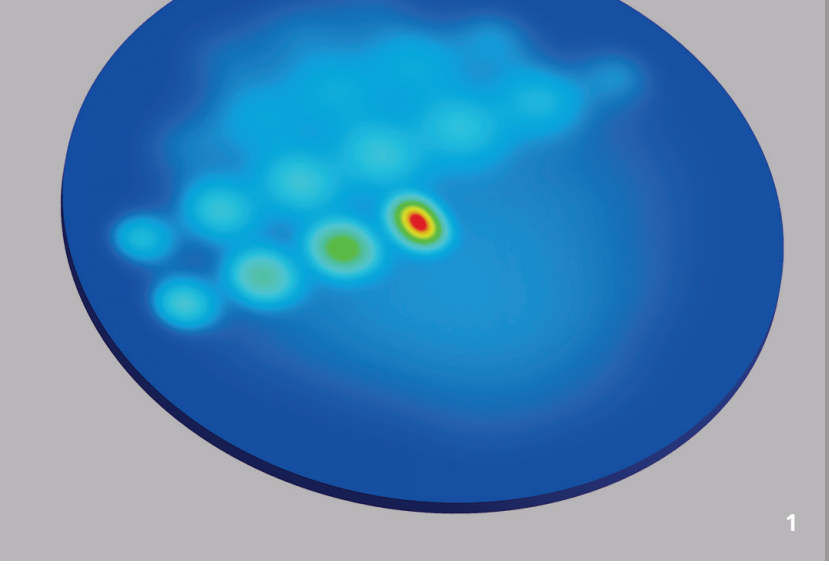
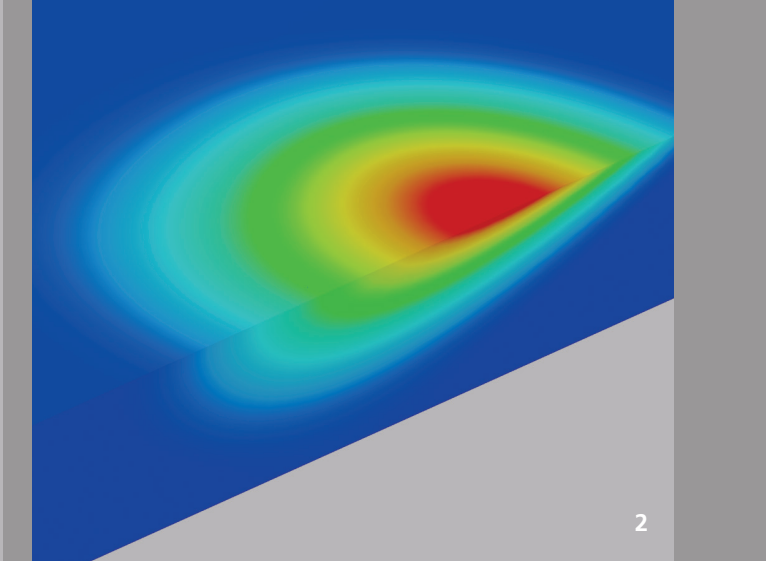


1



2

MULTIPHYSICAL SIMULATION OF THERMOOPTICAL EFFECTS IN THE LPBF PROCESS

Task

In the additive manufacturing process laser powder bed fusion (LPBF), the protective glass, which separates the optical unit from the building chamber, can become contaminated since condensate and powder particles can gather there, depending on the process and shielding gas guidance. This contamination increases the degree that the protective glass absorbs light and induces thermo-optical effects. Since the protective glass heats up, the focus position shifts and the scan vectors deviate from the desired positions, which in turn reduce process stability and contour accuracy. Due to the highly dynamic process control, the scan vectors cannot be determined experimentally. To counter these adverse effects, the Fraunhofer ILT in cooperation with the Chair for Technology of Optical Systems (TOS) at RWTH Aachen University has carried out multiphysical simulations to evaluate such thermal influences.

Method

The processing of cube structures is modeled in a multiphysical simulation. The optical system consists of a variable focusing optics and a galvanometer scanner. By coupling thermomechanical finite element analysis (FEA) and optical analysis with ray tracing, scientists at ILT/TOS can analyze how the transient heating of the protective glass influences the focus position.

The simulations investigate the influence of contaminated protective glass. The assumed degree of absorption is 0.5 percent. In addition, the distance between galvanometer scanner and protective glass is varied.

Results

If the protective glass is placed approx. 40 mm behind the galvanometer scanner, the thermally induced focus shift of approximately one Rayleigh length is approximately eight times greater than if it is placed halfway between the scanner and the powder bed. The reason: the thermal load on the protective glass is spatially and temporally more evenly distributed in the second case than in the first. In addition, the simulations predict a shift in the scan vectors. For cubes at the edge of the construction field, the shift amounts to seven track distances. In addition, thermo-optical effects cause a shrinkage of the cube area by about 2 percent.

Applications

The multiphysics simulations help to make the LPBF process more robust and optimize scanning strategies for reducing thermo-optic effects.

The R&D project underlying this report is being carried out under the grant number 13N13710 as part of the »Digital Photonic Production DPP« research campus.

Contact

Oskar Hofmann M.Sc.
Telephone +49 241 8906-395
oskar.hofmann@tos.rwth-aachen.de

1 Temperature distribution of the protective glass calculated by FEA.

2 Detailed view of the temperature distribution.