Improving laser material processing objective lenses towards better utilization of high brilliance light sources

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Abstract

Today's high brilliance Laser sources cause huge thermal effects on optical components, affecting process stability, which is crucial for effective industrial use.

The development of high power cw-laser sources @ 1030 to 1070nm as Disc- or Fiber- Lasers make sources of multi Kilo Watt available. These lasers provide huge laser power at smallest spot sizes with highest intensity, allowing high-speed processes. Those highly efficient processes are very sensitive to changes like focus shift.

In fact thermal lensing is limiting the use of high brilliance Laser sources in various processes. To overcome this issue, the public funded project "Brilliant Lasers in Production" (BriPro) was started in 2010 to overcome this challenge.

In a holistic approach manufacturing of optical material, optical and opto-mechanical design, manufacturing of optical components and coating, engineering and process design are subject to analysis and optimization. Well-known companies and institutions are working together, funded by the Federal Ministry of Education and Research.

Jenoptik represents competence in optical-, opto-mechanical design, manufacturing and coating of components and optical systems.

1 Simulation of thermal lensing

Jenoptik has developed a simulation method which allows simulation of the thermal lensing effect starting with a description of the incident laser beam, generating transient temperature profile and surface deformation using FEM method, uploading the FEM results to optics design software, generating three-dimensional refraction index distribution and calculate the propagation with respect to discrete time steps.

Using this method Jenoptik is able to characterize the thermal behavior of entire objective lenses as F-Theta lenses for example.

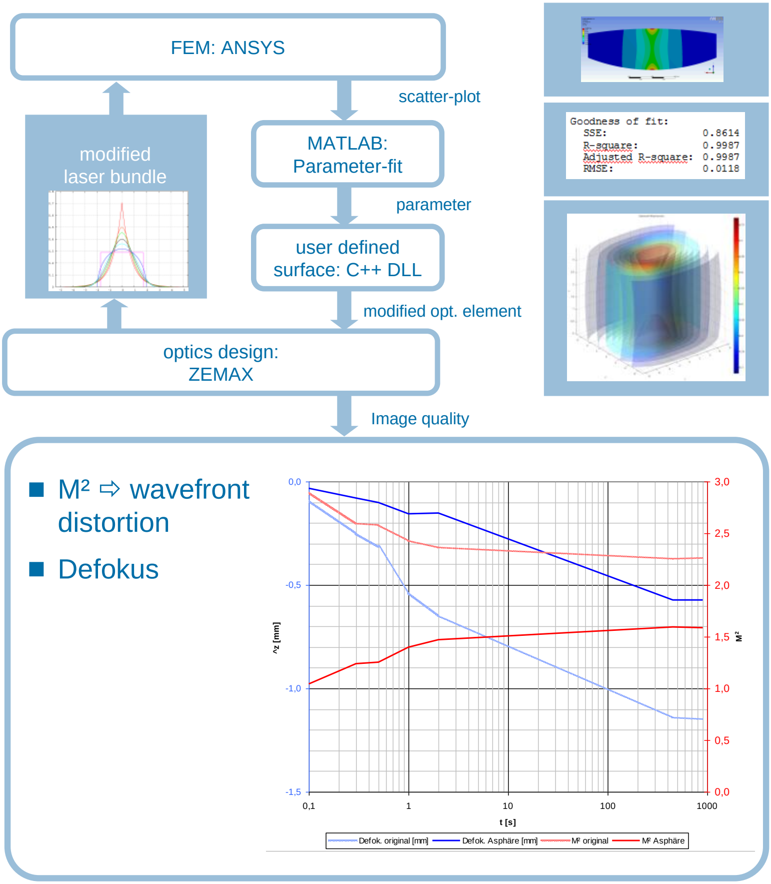

Figure 1: Jenoptik´s thermal lensing simulation Method

The simulation shows various time constants for thermal effects in bulk material, optical layers and adjacent structure like lens mount and – barrel. It is important to understand, which effects are to be addressed for optimization of components and systems.

Thus the specifications of absorption are set to less than 5ppm per Coating and the bulk absorption coefficient should be less than 50ppm/cm if optical glass is used.

2 Optics material selection

The BriPro project contains an extensive test program to characterize and identify feasible optical materials. They should have lowest absorption coefficients @1030-1070nm and should allow athermalization as well as achromatization.

The test program contained fused silica and various sorts of optical glass.

To characterize the test set components, various absorption measurement methods were used and compared. The reference method is the Laser induced deflection (LID) method by the Institute of photonic Technology (IPHT Jena). Other approaches are Jenoptik´s wave front deformation method (WFD), using a shearing interferometer and calorimetric methods used by TRUMPF and IFSW at University Stuttgart.

The results show, also with respect to thermal lensing simulation, that the absorption in optical glass, as it is state of the art, is too high for high power use. Thus optimization of optical glass by SCHOTT AG is running.

At the time being fused silica with absorption coefficients of 0,1ppm/cm or 15ppm/cm are used for optimized designs. Jenoptik already successfully tested focus shift of optimized F-theta lenses made of Fused silica.

Further approaches for optimization are optimized finish of optical surfaces and optical coatings with absorption less than 5ppm per surface.

3 Public funding

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