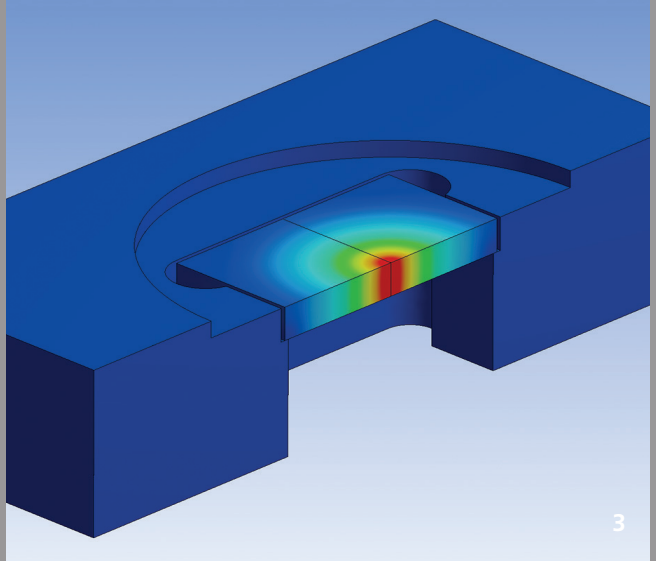

THERMO-OPTICAL EFFECTS IN PLASTIC OPTICS

Task

Thanks to injection molding, plastic optics can be manufactured with a high degree of design freedom and low costs per piece. Compared to optical glass, however, plastic has a high absorption coefficient in the range of 1%/cm. Moreover, the thermo-optic coefficient dn/dT and thermal deformation are about two orders of magnitude higher than that of glass. Consequently, significant thermo-optical effects are to be expected even at low thermal loads. Therefore, methods to model and compensate for these effects are required when plastic optics are used for laser applications in the power range of less than 10 W as well as for high-power LED applications.

Method

Finite element analysis is used to model the thermal load by absorption in the volume of the optics. The resulting temperature distribution and surface deformation are present in the form of discrete data. Thanks to specially developed software, the discrete data are transferred into continuously differentiable functions for the refractive index profile as well as the surface deformation and are made useable in the ray tracing program Zemax OpticStudio. In this way, thermo-optical effects can be taken into account when the optics are designed.

Results

Fraunhofer ILT has investigated the thermo-optical behavior of a polycarbonate planar plate with an IR laser beam source. Its simulation predicts a thermal refractive power of - 0.20 m^{-1} at 5 W laser power and a beam radius of 1.7 mm. Experimental measurements confirm the thermo-optical effects in the range of 1 to 20 W laser power.

Applications

The simulations allow a precise estimation of thermo-optical effects in plastic optics and, thus, form the basis for the development of compensation strategies. In a further step, practical plastic optics made out of different materials will be characterized.

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3 Finite element model of the polycarbonate sample.
4 Freeform optics made of plastic.