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INTRODUCTION TO PICOSECOND LASER OPTICS

Over the recent four years lasers with pulse lengths in the range from 1 ps to 10ps have become promising candidates for applications in materials processing and medicine. Picosecond pulses are short enough to allow „cold" materials processing, i. e. ablation without unwanted thermal effects such as melting of material and redeposition in the vicinity of the beam spot as it is known from materials processing with nanosecond lasers. The reason is that both thermal and field strength effects contribute to the interaction with the material. It is possible to produce holes or surface structures by one single laser processing step without mechanical or chemical treatment after laser irradiation. Medical applications have been demonstrated in the field of eye surgery and dentistry.

Moreover, picosecond lasers can often be constructed without complicated and expensive units for chirped pulse amplification. This make ps lasers compact and reduces the costs compared to femtosecond lasers. As for the materials processing, laser induced damage of the optics may result from both thermal and field strength effects. That´s why picosecond laser optics require specially designed optics to achieve high laser damage thresholds. In the following we show examples for HR mirrors and for thin film polarizers. For GTI mirrors which are often used for pulse compression from the ps range down to some hundred fs please see pages 50–51. Pump mirrors are presented at page 16.

MIRRORS

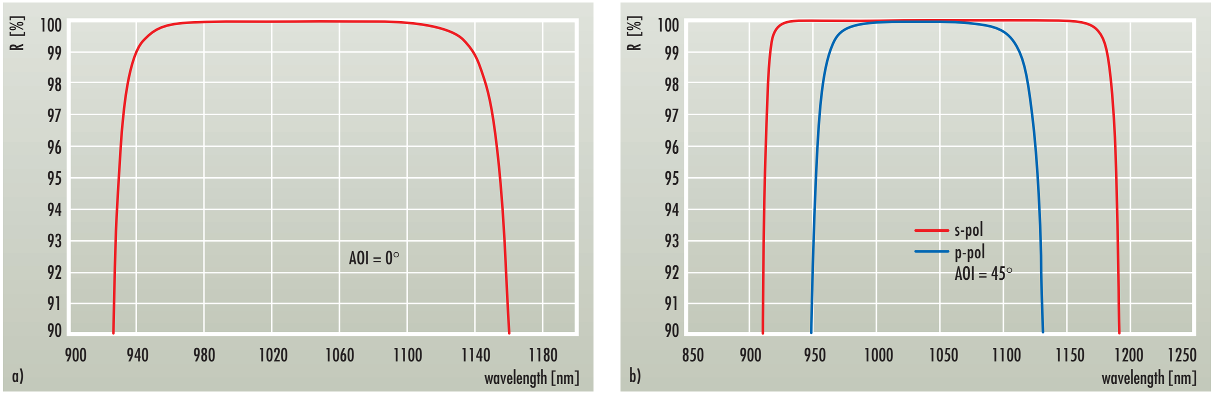

Figure 1: Reflectance spectra of a HR cavity mirror (a) and a turning mirror (b) for ps pulses at 1030 nm

High power mirrors were successfully used in several picosecond laser systems. Typical laser parameters are: energy density: **200mJ/cm²**, repetition rate: **240kHz, some 10^9 pulses.**

THIN FILM POLARIZERS

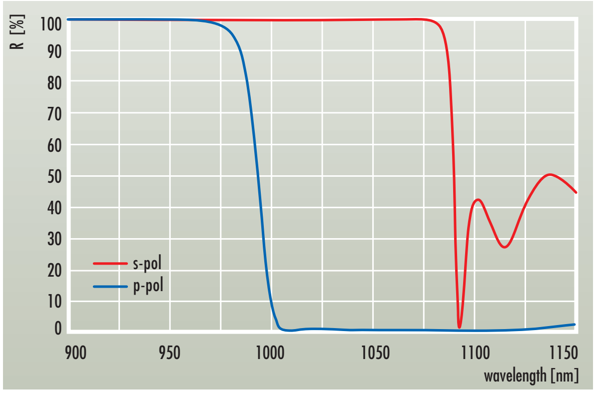

Figure 2: Reflectance spectra for s- and p-polarized light of a thin film polarizer which is designed for high laser damage thresholds for ps pulses (AOI = 55°)

Thin film polarizers are key elements for ps lasers, especially in regenerative amplifiers. Polarizers of the type shown above were successfully used with an energy density of **32mJ/cm²** at a repetitions rate of **240kHz** for **some 10^9 pulses.**

LASER INDUCED DAMAGE THRESHOLDS

Picosecond lasers work with repetition rates up to some 100kHz. Therefore, LIDT measurements must be carried out for large numbers of pulses and at high repetition rates. The investigations which are summarized below were carried out for up to 30000 pulses on one point of the sample. The variation of the number of pulses over some orders of magnitude gave also information on the damage behaviour at very high pulse numbers. We found that the LIDT values of the best mirror designs were constant for all numbers of pulses investigated while mirrors with smaller LIDT values show a decrease of the LIDT with increasing numbers of pulses. Thus, we predicted that the LIDT of the high power mirrors should remain high in the practical application with about one billion pulses per day. This is confirmed by customers who have used our high power mirrors for weeks without negative long time effects with respect to the damage threshold (see data on page 30).

Coating	Reflectance / wavelength	LIDT [J/cm²]*
Standard mirror	>99.9% / 800nm	0.55
High power mirror	>99.9% / 800nm	1.04
Single wavelength AR coating	<0.2% / 800nm	1.2 **
Broadband AR coating	<0.5% / 700–900nm	1.2 **

* Measurement conditions: 30000 pulses, repetition rate 1kHz, performed at Laser Zentrum Hannover and at Friedrich-Schiller-Universität Jena
** Self focussing effects may destroy the substrate while the AR coating is still stable