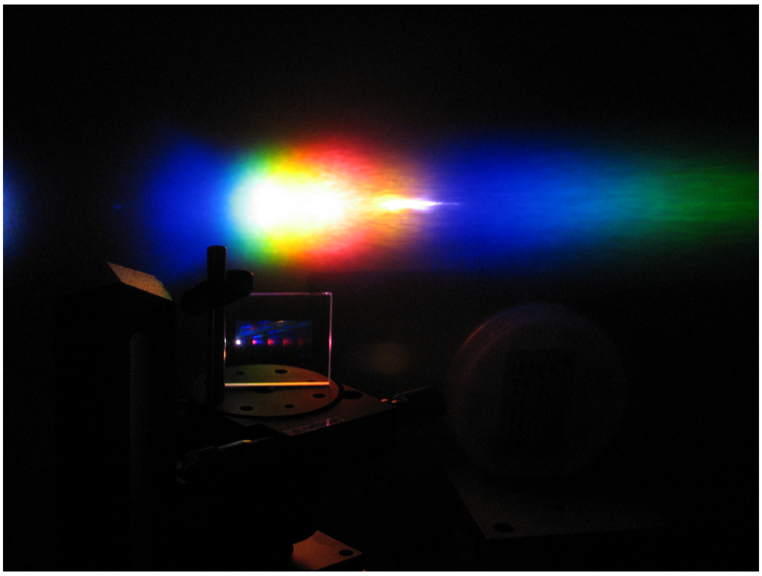
Laser induced damage threshold of an Ibsen transmission pulse compression grating FSTG-PCG-1250-1064



ICFO

Institut
de Ciències
Fotòniques

Attoscience and Ultrafast Optics ICFO

ICFO - The Institute of Photonic Sciences
Attoscience and Ultrafast Optics
Av. Carl Friedrich Gauss, 3
08860 Castelldefels (Barcelona) SPAIN
Phone: + 34 93 553 4002
Fax: + 34 93 553 4000

Introduction

The threshold fluence for laser induced damage on a transmission grating was determined. The grating of interest is a transmission grating designed for pulse compression operating at a center wavelength of 1064 nm with a grating resolution of 1250 l/mm made out of UV grade fused silica from Ibsen Photonics (FSTG-PCG-1250-1064). Measurements were conducted using the output of an amplified Ti:Sapphire laser system delivering pulses at 40 fs at a repetition rate of 3 kHz centered at 785 nm. The damage was then determined with a phase contrast microscope.

Procedure to determine the damage threshold

Figure 1 shows the beam profile at the equivalent grating plane. The effective area assuming a gaussian beam waist is 2.245×10^4 µm^2.

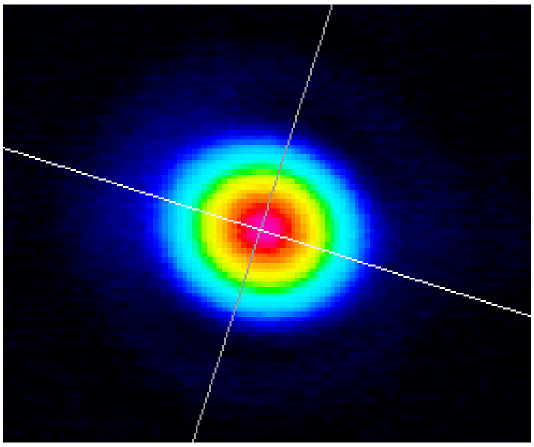


Figure 1: Beam profile at the grating plane.

The grating was exposed to different pulse fluences varying from 0.28 J/cm^2 to 1.22 J/cm^2. For that the pulses from a Ti:Sapphire laser system were sent through a half-wave plate mounted on a rotation mount followed by a polarising beam splitter to adjust the different energies. The beam was then focused with a lens (f=1m) and send onto the grating (Fig. 2). The grating was mounted on a x-y translation stage which was moved in a raster pattern for the different energies. Two measurement runs were performed applying the following fluences: 1.0572 J/cm^2, 1.2176 J/cm^2, 1.1433 J/cm^2, 0.9800 J/cm^2, 0.8018 J/cm^2, 0.6682 J/cm^2, 0.4826 J/cm^2, 0.3861 J/cm^2, 0.2851 J/cm^2 for the first run and 1.1879 J/cm^2, 1.1879 J/cm^2, 1.1136 J/cm^2, 1.0394 J/cm^2, 0.9800 J/cm^2, 0.8909 J/cm^2, 0.7424 J/cm^2, 0.5791 J/cm^2 for the second run.The exposure time for every tested spot was 5 s. A reflection of the spectrum and the 1st order of the grating were monitored by a spectrometer (HR 4000, Ocean Optics).

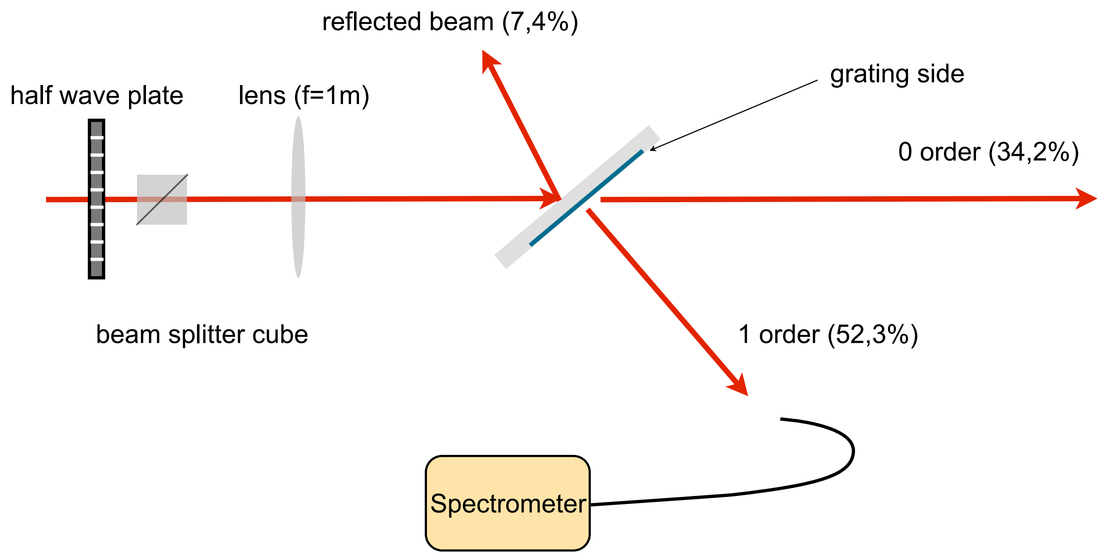


Figure 2: Experimental setup for testing the damage threshold of the grating. The percentages indicate the amount of energy in the diffracted and reflected beams compared to the incident beam.

In a second step the easily visible damages were identified with a microscope having a magnification of 10. To determine the physical damage for the different fluence levels around the damage threshold, a phase contrast measurement (magnification 40) was performed.

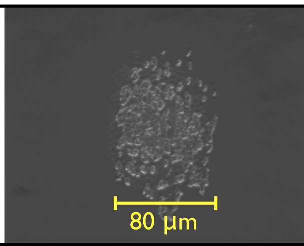
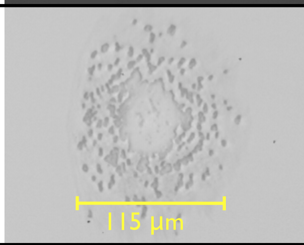
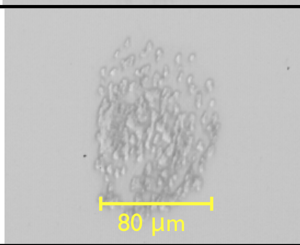
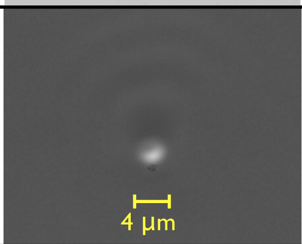
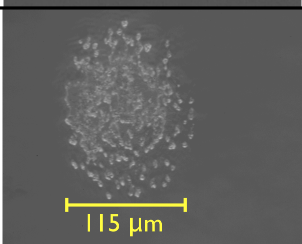
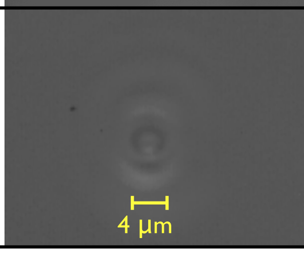
Fluence	Microscope	Comment
1.22 J/cm²		Backscatter, white spot visible by eye and SPM. Magnification 40x.
1.19 J/cm²		Backscatter, white spot visible by eye and SPM. Magnification 10x.
1.19 J/cm²		Backscatter, white spot visible by eye. Magnification 10x.
1.14 J/cm²		No spectral broadening. Magnification 40x.
1.11 J/cm²		Backscatter, white spot visible by eye and SPM. Magnification 40x.
1.04 J/cm²		No spectral broadening. Magnification 40x.

Figure 3: The table shows different kinds of damages for different fluences. The pictures with a magnification of 40 were captured with a phase contrast microscope.

Results and discussion

The goal of this test was to determine at which fluences physical damage on a transmission pulse compression grating appears. Self-phase modulation (SPM) was already detected at much lower intensities, but was not part of this investigation. For more information regarding nonlinear effects in Ibsen transmission gratings see [1].

For all tested fluences no damage to the actual grating lines could be identified. The damage always occurred on the UV-grade fused silica side which agrees with the self-collapse distance estimated with a simple approximation [3]. The latter lies between 1.1 mm and 2.2 mm for input intensities of 30.4 TW/cm^2 to 7.1 TW/cm^2 respectively. In Figure 3 you can see the microscope images of the fused silica side of the grating showing damage for fluences above 0.98 J/cm^2 or 23 TW/cm^2.

The lowest fluence for which laser induced damage on the grating was observed is 1.04 J/cm^2, corresponding to a peak intensity of 24.4 TW/cm^2, which is consistent with the measurements on dielectrics taken by Lenzner [2]. For fluences between 1.04 J/cm^2 and 1.14 J/cm^2, the damage mostly appeared as a small approximately 4 micron diameter spot under the phase contrast microscope, but could not be detected using the normal microscope with a magnification of 10. Above 1.14 J/cm^2, the damage appeared as a collection of spots with an overall diameter of approximately 100 micron.

References

[1] Ibsen Photonics in corporation with Center for Advanced Photonics Research at Temple University. Assessment of threshold for nonlinear effects in ibsen transmission gratings. Technical report.

[2] M. Lenzner, J. Krüger, S. Sartania, Z. Cheng, Ch. Spielmann, G. Mourou, W. Kautek, and F. Krausz. Femtosecond optical breakdown in dielectrics. *Phys. Rev. Lett.*, 80(18):4076–4079, May 1998.

[3] J.H. Marburger. Self-focusing: Theory. *Progress in Quantum Electronics*, 4(Part 1):35 – 110, 1975.