Deliverable 4.1: Report on simulation of pulse compression gratings with diffraction efficiency >=99% over large spectral bandwidth (5-10 nm) around 1030 nm

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Context

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Declaration: Any work or result described therein is genuinely a result of the Hiperdias project. Any other source will be properly referenced where and when relevant

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1 Version History

Version	Summary of Change	Written By	Approver	Date
0.01	N/A			

2 Introduction

The objective of the present deliverable is to perform a design of the grating compressor which will be integrated within the amplifier chains i.e. in both the 200W developed at AMP and also the 500-1000W developed at USTUTT.

3 Specification of grating parameters

During the kick-off meeting, the grating period (line density) as well as the AOI-AOD has been agreed between AMP, AMO and USTUTT. The central wavelength is chosen to be 1030 nm which corresponds to the central wavelength for the Yb:YAG laser systems which will be developed within HIPERDIAS.

The input specifications/targets for the design are summarized in the following table:

Grating period	610 nm (1640l/mm)
Angle of incidence	51.4°
Separation angle	13.7°
Diffraction efficiency at 1030 nm	99.5%
Spectral bandwidth at efficiency >99%	5-10 nm
LIDT in fs-ps operation	>0.3 J/cm²
Grating dimensions	75mmx50mm

4 Design results

The grating design which will be developed within Hiperdias is based on the so-called leaky-mode grating mirrors as described in ref. [1: Martin]. A schematic of the grating cross-section is shown in figure 1.

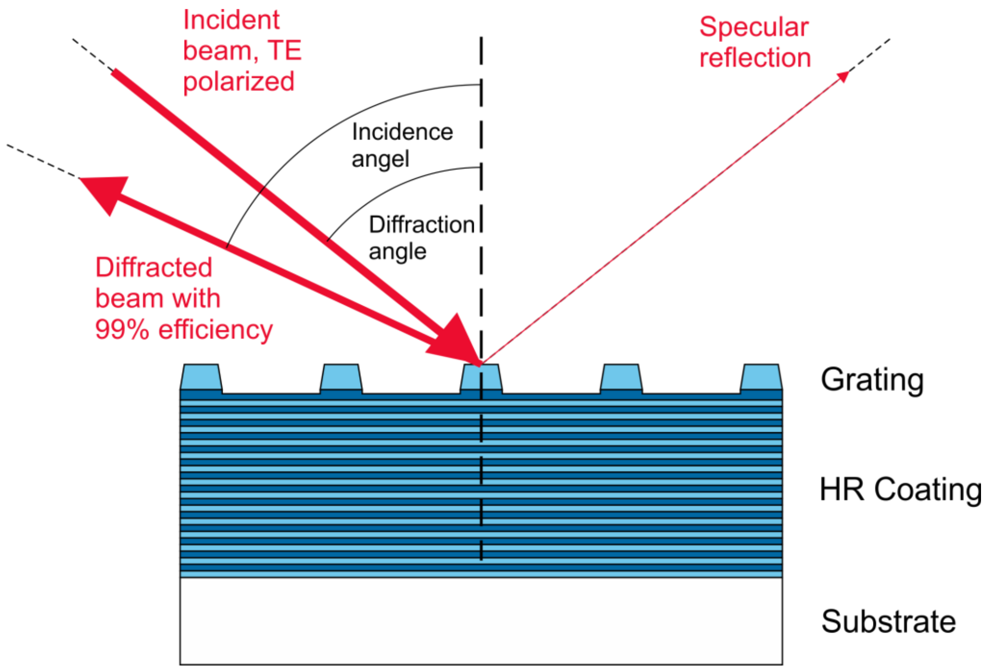

Figure 1: Cross-section of grating compressor

The grating is composed of a fully dielectric multilayer coating combined to a leaky waveguide in order to give rise to resonances which lead to high diffraction efficiency. Using commercially available codes as well as self-written simulation tools, USTUTT has implemented a structure which is composed of an overall of 30 alternating Ta_2O_5/SiO_2 layer (coated on fused silica substrate). The choice of Ta_2O_5 and SiO_2 dielectric material was driven by the fact that these are commonly used in dielectric mirrors.

Figure 2 shows the calculated diffraction efficiency for TE polarization. As can be seen at 1030 nm, diffraction efficiency higher than 99.9% in the -1st order is achieved theoretically. The spectral bandwidth of the grating response at an efficiency >99% is calculated to be more than 20 nm.

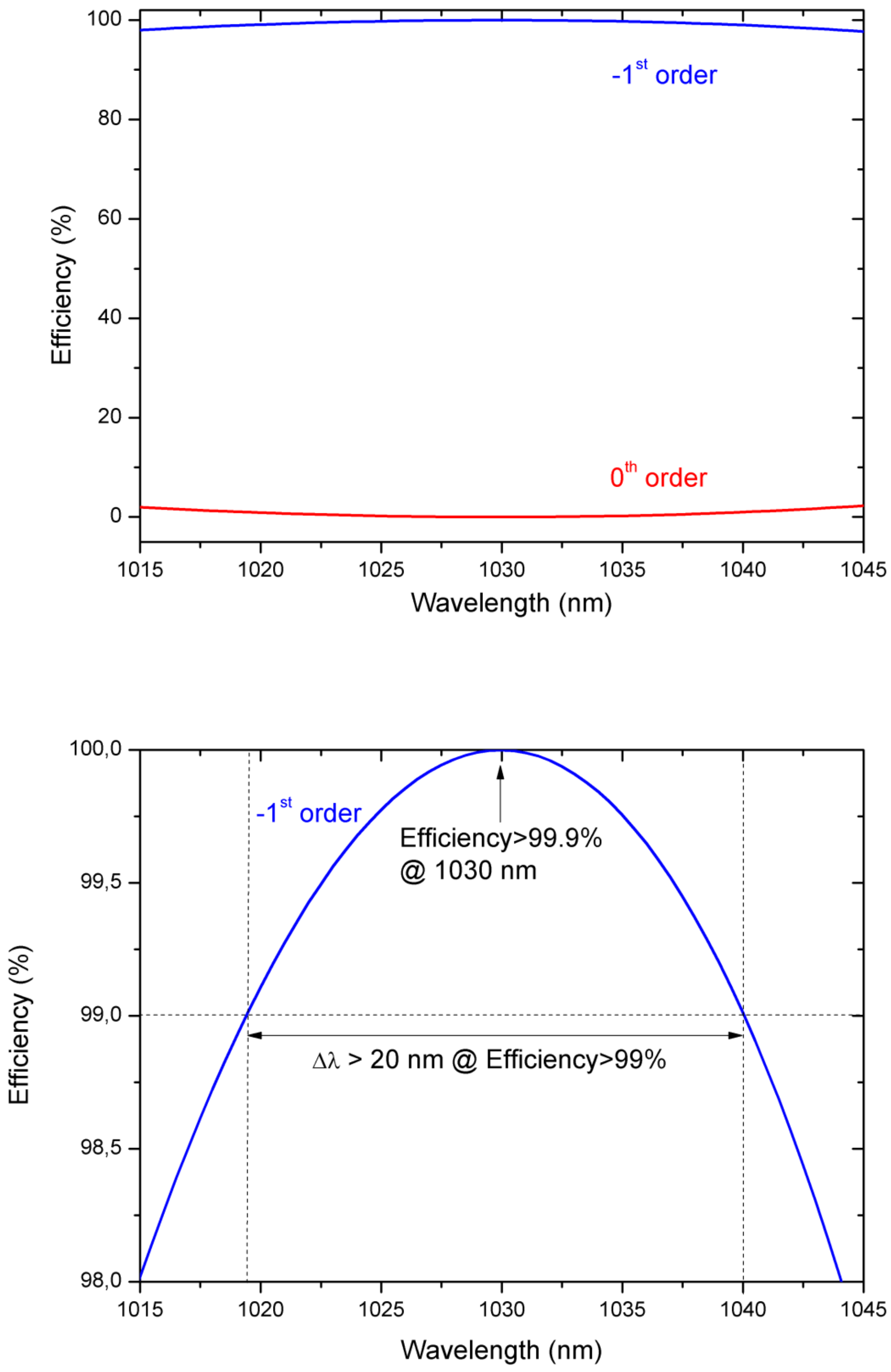

Figure 2: Calculated diffraction efficiency for TE polarization

Furthermore the LIDT was evaluated based on the theory reported in ref [2: Gallais] and by calculating the field distribution inside the grating mirror layers as can be seen in figure 3. The simulation led to a LIDT ranging between 0.3 and 0.5 J/cm².

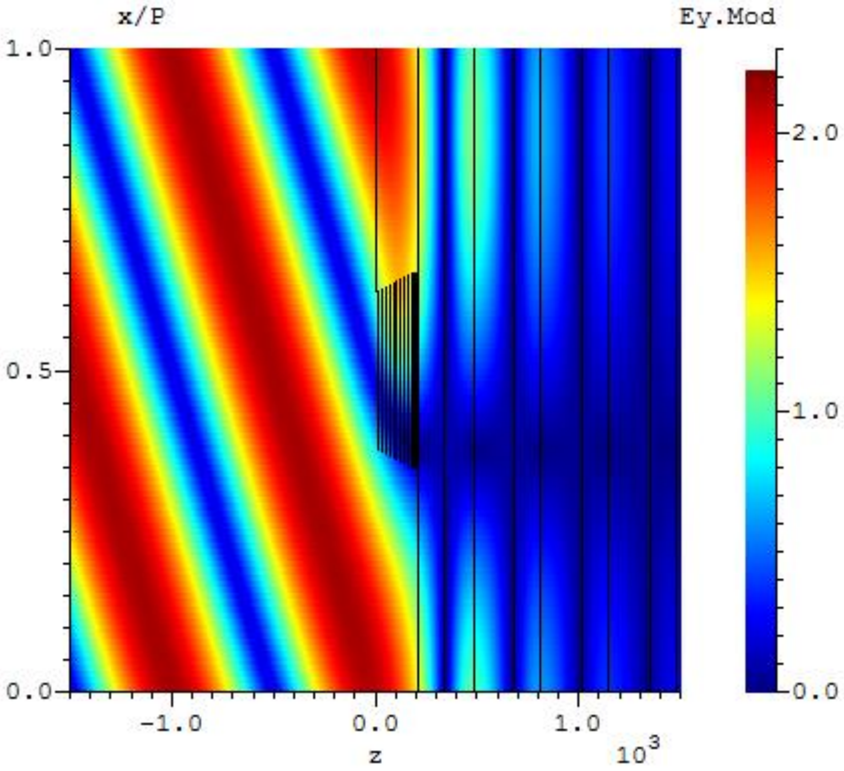

Figure 3: Calculated field distribution inside the grating mirror layers

5 Conclusion and summary

Table 2 summarises the calculated grating compressor performances. For comparison purposes, The targeted values are also added in the table. As can be seen all targets specified within the DOA has been achieved within the simulation results.

	Targets	Obtained design results
Period	610 nm	610 nm
Angle of incidence	51.4°	51.4°
Separation angle	13.7°	13.7°
Diffraction efficiency at 1030 nm	99.5%	**>99.9%**
Spectral bandwidth at efficiency >99%	5-10 nm	**>20 nm**
LIDT in fs-ps operation	>0.3J/cm²	**0.3 -0.5 J/cm²**

The parameters of the grating have been communicated to partner AMO for the sub-sequent fabrication process of the elements.