Operational damage to Petawatt gratings

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During a regular inspection of the optics within the Petawatt Compressor Chamber[1)] in June 2004 a significant change was observed on the first grating[2)] of the compressor. A thin arc of approximately thirty centimetres length and, at maximum, 1 cm thick was discovered passing through the 'parsons nose', an artifact of the manufacturing process (see figure 1a). There was a further damage mark on the left of the grating which was considerably shorter than the central mark at about 5 cm long (see figure 1b).

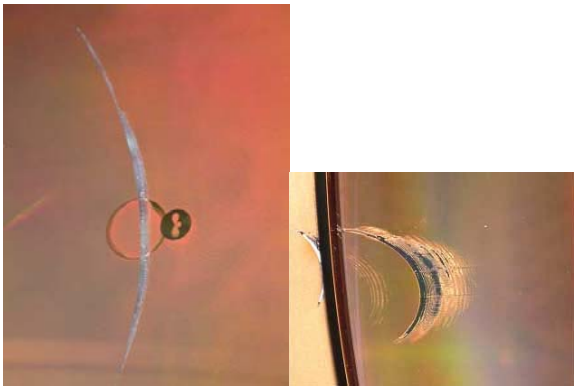

Figure 1. a) Central damage mark on first grating. b) Left side damage mark on first grating.

On further investigation it was noted that the damage had removed the gold top layer and had made significant damage to the photoresist layer.

An investigation into the cause of the damage noted that the gold on the bezel at the right of the grating was suffering from burn damage. It was suggested that the beam had a near-field mismatch into the grating such that it hit the bezel and burnt through the gold. The beam then traveled through the substrate reflecting off the back onto the centre mark, a fraction was reflected off to do another bounce and form the second damage mark on the left of the grating.

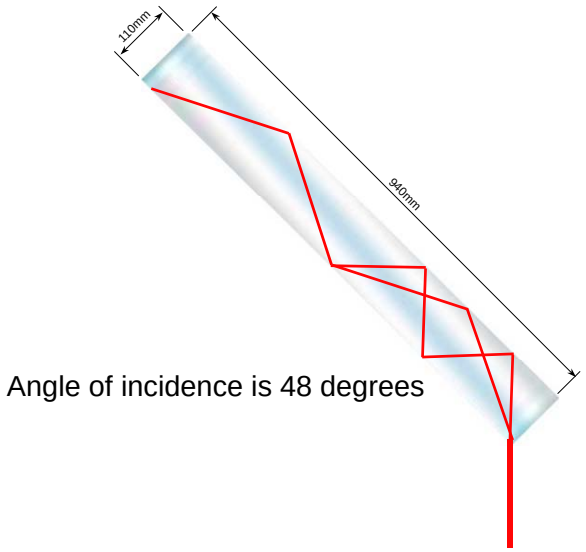

Figure 2. Diagram showing how the damage occurred to the first grating.

In the process of testing this theory by aligning a helium neon laser along the beamline edge the laser fitted exactly with the damage marks. This did not however equate to passing through the damaged bezel, but through the polished side of the grating. This also accounted for the effective focusing action due to the curved shape of the edge of the grating (figure 2). When aligned through the bezel a double bounce was observed but arrived at the front surface a quarter and a half of the way across the grating. On further inspection there is a very faint damage mark a quarter of the way across the grating. To prevent further damage an edge shield (figure 3) was designed and installed covering the edge and bezel of the grating.

By applying a similar technique it became apparent that the damage on the second grating[2)] was also caused by passage through the side of the grating due to the grating being overfilled. Another edge shield was installed on the second grating.

Conclusion

Significant damage has been seen on the first grating in the Petawatt compressor. The cause of this damage has been found and shields installed to prevent it re-occuring.

References

1. CN Danson *et al.*, 'Vulcan Petawatt – Design, Operation and Interactions at 5.10^{20} $Wcm^{-2.}$ Laser and Particle beams (2005), 23, 87-93
2. T Winstone *et al.*, 'Operational experience of Petawatt Gratings on Vulcan', Central Laser Annual Report RAL-TR-2003-018

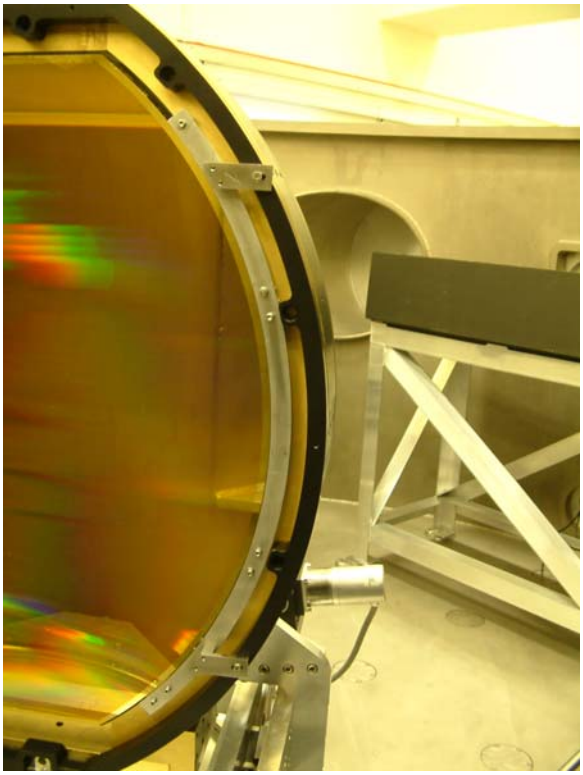

Figure 3. Grating showing edge shield.