19p-C2-9

大型高効率透過型グレーティングの波面解析

Wavefront Analysis of High-Efficiency, Large-Scale, Thin Transmission Gratings

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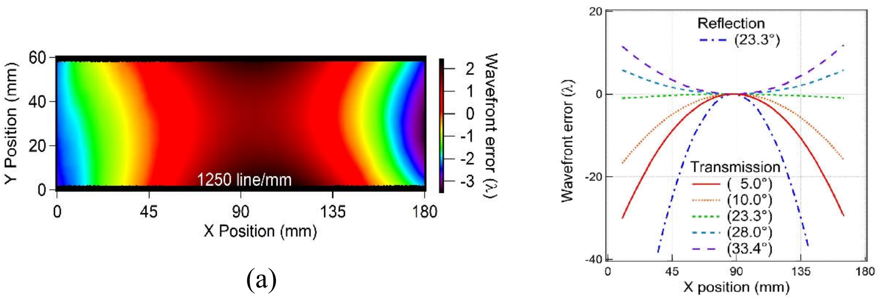
Large-scale, high-efficiency transmission gratings (TGs) are attractive for terawatt (TW)-class Ti:sapphire lasers because of high damage threshold and long lifetime. We developed new TGs with a size of 180 × 60 × 1 mm^3 and groove densities of 1740 and 1250 lines/mm by using optical lithography [1]. Both gratings showed diffraction efficiencies above 95% and a compressor throughput up to 80%.

To determine the deformation of the TGs, we measured the wavefront distortion of the beam reflected from a TG by a Zygo interferometer equipped with a He–Ne laser (633 nm). The two-dimensional (2-D) wavefront distortion $W(x, y)$ is related to the deformation of the grating $H(x, y)$ by $W(x, y) = 2H(x, y)$, where x and y are the axes across and along the groove direction, respectively. We observed a clear parabolic bending of the grating with AR coating by the ion-assisted deposition method. The peak to valley (PV) values of the bending over the total area are distributed from 44 to 52 λ at 633 nm among 5 samples. The bending was reduced by one order of magnitude by adding a negative bending with a SiO_2 under coat and by AR coating with e-beam deposition. Figure 1(a) shows a 2-D wavefront map of $W(x, y)$. The bending is considerably reduced to PV = 2.9 λ in $H(x)$ [PV = 5.8 λ in $W(x)$].



(a)　　(b)

Fig. 1(a) Reflected wavefront map of a grating with a groove density of 1250 lines/mm at 633 nm.

(b) Wavefront error in λ at 633 nm versus grating position along the dispersive direction.

By a simply 1-D analysis, $W(x)=2(\cos\beta_0-\cos\alpha_0)H(x)$ for a double-passed TG, while $W(x)=2(\cos\beta_0+\cos\alpha_0)H(\mathrm{x})$ for a reflective grating (RG), where β_0 and α_0 are the diffracted and incident angles, respectively. This relation shows that the spatial bending does not induce a wavefront distortion through the TG in the Littrow condition of a monochromatic beam (α_0=23.3°), while the wavefront distortion is approximately two times the spatial bending in the case of a RG as in Fig. 1(b). The wavefronts are almost flat in TG but largely parabolic in RG respectively near the Littrow condition or even in TG at off-Littrow angles. Although femtosecond pulses contain a broad spectrum, this fact explains why a pulse compressor with TGs is considerably less sensitive to the bending than that of RGs.

Reference:　[1] C. Zhou, T. Seki, *et. al.* Opt. Express **22**, 5995-6008 (2014).