L.5: Compensation of phase errors in a tiled single grating laser pulse compressor

The output intensity of any Chirped Pulse Amplification (CPA) based high energy, high peak power laser system ultimately depends on the aperture of the gratings used in the laser pulse compressor system. For PW lasers, the required grating size is larger than a meter. Coherent tiling of small sized gratings provides a beautiful low cost alternative to such large size gratings, which are otherwise technologically challenging to manufacture. However, coherent alignment of gratings and maintaining the alignment with sub wavelength precession over a long period of time and lengths is practically difficult. At Advanced Lasers and Optics Division (ALOD), we have been designing and developing the tiled grating pulse compressors having different optical configurations.

Earlier, we have reported three new configurations of single tiled grating laser pulse compressor. These configurations have certain advantages like: compactness, reduction in cost, ease of alignment and maintenance because they have just one tiled grating surface. Recently, we worked out another optical design with single tiled grating surface having added benefit of self-compensation of various tiling alignment errors. For a tiled grating assembly of two gratings, there are in total six alignment errors: three rotational errors tip, tilt and in plane rotation (due to rotation about three orthogonal axis), two piston errors (due to translation perpendicular to the grating grooves) and groove density mismatch error between the two gratings. Experiments have been carried out in our laboratory to demonstrated compensation of tip error, groove density mismatch error and the two piston errors, in the new optical design of tiled single grating pulse compressor. In addition to the compensation of tiling errors, the new design of pulse compressor can accommodate laser beams having diameter up to two times larger than our earlier designs for a given value of compression length.

The schematic design of the new tiled single grating pulse compressor is shown in Fig. L.5.1. In the new pulse compressor with tiling error compensation, all the four hits of laser beam are spatially symmetric with respect to tiled grating junction as can be seen from the schematic design. After each hit on the grating assembly, the laser beam is horizontally inverted with respect to the grating junction either by the horizontal retro-reflecting mirrors (HRR) or by mirror M1 and M2. The horizontal inversion and symmetric incidence on the tiled grating assembly results in the compensation of the tip error, groove density mismatch error and the two piston errors.

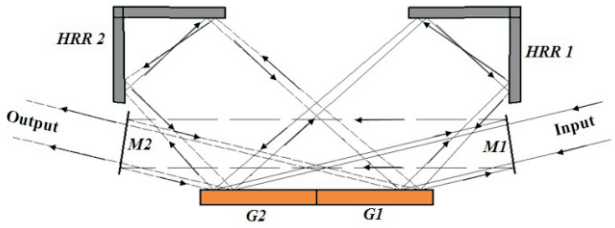

Fig: L.5.1: Schematic design of the new tiled single grating pulse compressor

Far field studies have been performed to show the desired compensation of the tiling errors takes place in the new compressor using a He-Ne laser and has been shown in Fig. L.5.2. The tiling phase errors lead to the distortions in the focal spot pattern of the beam diffracted by the tiled grating assembly. For example, in the presence of piston phase error of π, the focal spot splits into two. This focal spot splitting is visible in the beam after the first grating hit (see Fig. L.5.2(a)). However, after two hits on the tiled grating assembly a single focal spot is observed (see Fig. L.5.2(b)), showing the phase error compensation.

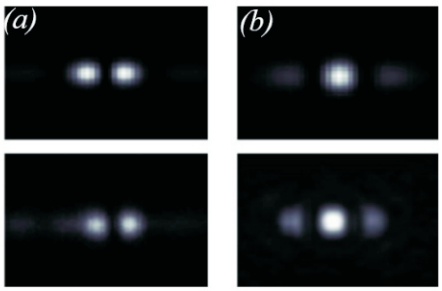

Fig: L.5.2: Simulated (top row) and measured (bottom row) far field intensity distribution after first hit on the tiled grating junction (a) piston error of ~π; and (b) Compensation after two hits

A pulse compressor was setup with the proposed design for the compression of stretched 650 ps positively chirped laser pulses. Duration of the compressed pulse, for the tiled single grating pulse compressor was estimated to be 235 ± 10 fs which is close to the measured pulse duration of 200 ± 10 fs for the case of single monolithic grating replacing the tiled grating assembly. For details, please see D. Daiya et al, Opt. Commun. 389,165 (2017).

Reported by:
D. Daiya (deepakd@rrcat.gov.in) & A.S. Joshi