Realization of Tiled-Grating Compressors for the OMEGA EP Petawatt-Class Laser System

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**Summary**

Two large-scale tiled-grating compressors have been activated for the OMEGA EP Petawatt-Class Laser System.

- Eight tiled-grating assemblies (TGA’s) have been built, tiled, and demonstrated submicroradian stability.
- The automatic tiling processes for aligning individual TGA’s and optimizing overall tiling performance have been implemented.
- Two tiled-grating compressors have been integrated and activated.
- Tiling did not degrade focal-spot performance.
- Both compressors achieved subpicosecond-pulse durations.
Collaborators

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OMEGA EP requires two tiled-grating compressor systems to meet energy and focal-spot requirements

- **OMEGA EP requirement**
  - Energy-on-target: 2.6 kJ  
  - Pulse width: 1 to 100 ps

- **Beam size on gratings**
  - 1.23 m on G1 and G4; 1.28 m on G2 and G3;
  - Size of individual gratings: 0.47 m × 0.43 m

**Three tiles are interferometrically aligned to generate a 1.5-meter-sized grating.**

The grating compressor chamber (GCC) has been integrated, aligned, and activated.

Upper-compressor view
- Four tiled-grating assemblies (TGA’s)
- Fizeau tiling interferometer
- Vacuum-compatible DM
- Beam combiner
- Short-pulse diagnostic package

G8222
Each TGA is tiled using an interferometric technique inside the grating compressor chamber at vacuum.

- Compressor alignment performed using only single central tiles
- A built-in Fizeau interferometer is used to tile each individual TGA
  - TGA, selection mirror, and reflection mirror are rotated to align each outboard tile relative to the central tile
  - Near-field tiling is realized using an interference pattern formed by the reference beam from the TF and the testing beam from two adjacent tiles and the RF.
Fourier fringe analysis is used to tile each individual TGA

Interferogram near field

Fourier transform of the interferogram

Filtered first harmonic signal

Calculate relative tilt, tip to the TF; recover phase

Outboard tile

Central tile

Wavefront of the two tiles

\[ \text{rms} = 0.4984 \lambda \]

\[ x \text{ (mm)} \]
\[ y \text{ (mm)} \]

Eight OMEGA EP production TGA’s have been successfully tiled

- All eight TGA’s have been tiled and tested outside the GCC before being installed
  - Each TGA was tiled for its GCC use configuration using a 24-in. Fizeau interferometer
  - The tiled wavefronts of all qualified TGA’s maintained for at least 12 h

- All eight TGA’s have been retiled in the GCC at vacuum
  - Tiled positions are maintained by closing the actuator control loop with feedback of position-displacement sensors.
  - Submicroradian angular stability is achieved
The final tiling performance is optimized using a far-field method by adjusting TGA4.

- All eight TGA’s are rotated to the aligned compressor positions after being individually tiled.
- Each of the two outboard tiles of TGA4 is used to remove the residual tiling errors from three other tiles of TGA1 to TGA3 corresponding to the same side of the beam.
- The far-field tiling-optimization process is automated.
The triple-tile compressor offers a tighter focal spot than the sub-aperture single-central-tile compressor

- Far field was measured for both single-central-tile and triple-tile configurations

- FWHM ratio:
  - X lineouts = 3:1
  - Y lineouts = 1:1

- The triple-tile compressor delivered a tighter far-field spot than the single-central-tile configuration.

No degradation of spatial properties due to tiling
Subpicosecond pulses are obtained with the two tiled-grating compressors

- Decorrelated pulse width of the two compressors are obtained (decorrelation factor = 1.34)
- Subpicosecond pulses obtained on both compressors

<table>
<thead>
<tr>
<th></th>
<th>LC (fs)</th>
<th>UC (fs)</th>
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</thead>
<tbody>
<tr>
<td>Single tile</td>
<td>630</td>
<td>600</td>
</tr>
<tr>
<td>Triple tile</td>
<td>630</td>
<td>600</td>
</tr>
<tr>
<td>Transform limit</td>
<td>400</td>
<td>410</td>
</tr>
</tbody>
</table>

No degradation of temporal properties due to tiling.
Summary/Conclusions

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