Tiled Grating Pulse Compressor: An important element of the new OMEGA EP (extended performance) laser system is the grating compressor used to form short pulses of light at the output of the system. The most-promising technology is a holographically formed and etched grating combined with a multilayer dielectric (MLD) coating to form a highly efficient grating used in reflection. Gratings with high damage threshold ($\gtrsim$1 J/cm^2) and large aperture (~1 m) are required for the OMEGA EP laser system. In pursuit of an alternative to meter-sized MLD gratings, LLE is investigating the coherent addition of multiple small gratings to form a larger grating. We refer to this approach as grating tiling.[1] Recent experimental work at LLE demonstrates that grating tiling is a viable approach toward energy scaling of pulse-compressed laser systems.[2]

Figure 1. Photograph of tiled grating assembly. The gratings are artificially illuminated by an external light source.

Two gratings with a groove density of 1740 g/mm, manufactured by Jobin–Yvon, were independently mounted within a precision assembly to achieve coherent addition (Fig. 1). Accurate control of the relative position and orientation of the grooves of each grating offers a significant but achievable challenge. To accomplish this control, the tiled grating assembly was located within a diagnostic package consisting of a Fizeau interferometer and a focal-plane sensor. This diagnostic package provided precision control of the phase front, thus allowing controlled studies of the focal-plane irradiance.

Initially, the feasibility of grating tiling was demonstrated with monochromatic laser light. With the aid of the diagnostics package, the tiled gratings were systematically aligned to achieve a near-diffraction-limited focal spot. As shown in Fig. 2, the measured diameter (red) was only 1.2 to 1.3 times larger than that of the diffraction-limited beam (blue). In comparison, the focal plane diameter resulting from a beam with a π piston phase error (green) is calculated to be 2.4 times larger than that of a diffraction-limited beam. The small difference between calculation and measurement is attributed to the wavefront quality of the individual gratings. More recently, high-fidelity pulse compression of a chirped-pulse-amplified (CPA) laser was demonstrated using tiled gratings. Upon substitution of a pair of tiled gratings for a single-grating compressor, a Fourier-transform-limited, 650-fs, CPA laser pulse was maintained. The autocorrelation traces of Fig. 3 show negligible pulse broadening and distortion with the tiled gratings and thus indicate accurate control of their relative position as well as accurate alignment of the grating compressor.

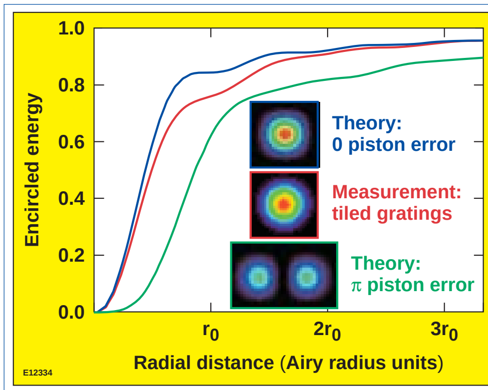

Figure 2. Plots of calculated encircled energy fraction for piston phase errors of 0 (blue) and π (green) compared to actual measurement with two tiled gratings (red).

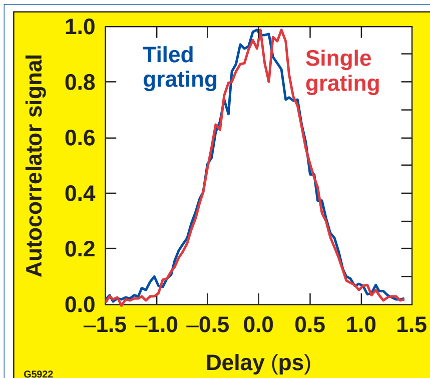

Figure 3. Autocorrelator traces of Fourier-transform-limited, 650-fs pulses produced by single-grating (red) and tiled grating compressors (blue).

Based on extensive first-hand experience with grating tiling, including laser pulse compression, a design approach is being established for the OMEGA EP system. A complete system prototype, including hardware and software, will be developed in advance of the OMEGA EP activation date.

OMEGA Operations Summary: During June, a total of 98 target shots were provided by OMEGA for LLNL (31 shots), CEA (5 shots), and LLE (62 shots) experiments. A full week of scheduled system maintenance was also conducted, and the capability to convert one OMEGA beamline to fourth-harmonic operation was implemented.

1. T. J. Kessler, J. Bunkenburg, and H. Huang, "Grating Array Systems for the Alignment and Control of the Spatial and Temporal Characteristics of Light," U.S. Patent Application (filed May 2003).
2. J. Bunkenburg, T. J. Kessler, H. Hu, C. Kellogg, and C. Kelly, "Coherent Summation of Holographic Gratings for Pulse Compression Within Petawatt Laser Systems," presented at CLEO 2003, Baltimore, MD, 1–6 June 2003.