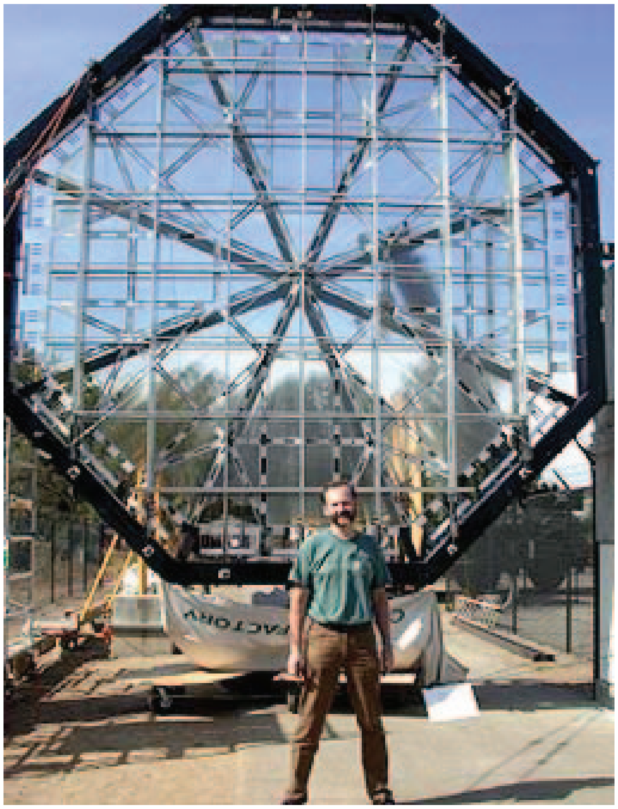
Advanced Optical Components & Technology

Technologies

The Eyeglass Space Telescope

Achieving greater resolution and signal-to-noise ratio than is currently possible in telescopic examination of distant astronomical bodies, such as galactic nuclei or extra-solar planets, requires a telescope with an aperture of 25 to 100 meters. Eyeglass is a new type of space telescope consisting of two cooperating spacecraft separated in space by a few kilometers. A large-aperture primary lens (magnifying glass) collects light and a secondary lens (eyepiece) moves along the focal surface for imaging. Eyeglass uses diffractive optics (also called Fresnel lenses, flat on one side and ridged on the other – see below) instead of mirrors or conventional glass lenses.



LLNL's Fresnel lens, mounted in a steel and aluminum frame and ready for optical testing.

Diffractive telescopes with Fresnel lenses fabricated on thin membranes offer several advantages over telescopes that use mirrors: thin-membrane lenses are lightweight, packageable, and space-deployable. Transmissive diffractive lenses are significantly less sensitive to surface deformations than mirrors, and the chromatic effects of the diffractive primary can be completely compensated for.

As a first step in developing the Eyeglass technology, LLNL scientists built and tested a small-aperture (20-cm), color-corrected diffractive telescope and obtained a broadband image of the lunar surface. Next, they built and demonstrated an 80-cm-aperture segmented, foldable lens.

In 2002, the researchers constructed a 5-m, f/50 Fresnel lens – comprising 72 segments patterned with binary Fresnel arcs in photoresist – and secured it to a 750-μm-thick sheet of glass with UV-curable cement and metal tabs. The assembled lens was mounted in a frame and the focal spot of a white-light source mounted at the opposite focus was imaged. This demonstration lens was not made to give diffraction-limited performance, but to demonstrate assembly and deployment at a scale large enough to be of interest for imaging.

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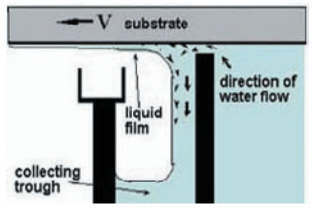
Wet-etch Figuring

AOCT developed wet-etch figuring (WEF) for precision optical contouring of transmissive optics via the controlled application of a liquid etchant. Some advantages of WEF are:

- The etchant's footprint is confined and stabilized by surface-tension gradients (Marangoni effect)
- Interferometry is used for real-time, closed-loop control of figuring in a completely automated process
- No mechanical or thermal stresses are exerted on the workpiece
- Ultrathin (<<1mm) glass can be figured to optical tolerances
- Conducted in an ambient environment, unaffected by temperature, vibration, etc.
- Tool footprint can easily be tailored to required figure gradients
- Glass panels as large as 1150 x 850 mm can be figured.



The Marangoni Effect in WEF

In the absence of surface tension gradients, the viscous drag of the moving substrate leaves a thin film of water on the hydrophilic surface (see image at right).

The surface-tension gradient between a thin film adhering to a substrate and a free surface of falling film is strong enough to pull etchant off of the substrate surface. Regardless of substrate movement, the wetted zone remains stationary relative to the applicator. The Marangoni effect can also be thermally driven.

AOCT has designed linear and circular "spot" toolheads for 1- and 2-dimensional figuring.