The Status of the MERCURY Laser

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The MERCURY laser is a high-efficiency, gas cooled solid-state laser designed to produce 100J at 10Hz.

**Goals 2 amps:**
- 100 J
- 10 Hz
- 10% Efficiency
- 2-10 ns
- < 5X Diffraction limit
- > 10^8 shots

**Gas-cooled amplifier heads**
- Helium gas flow at 0.1 Mach

**Front-end**
- 300 mJ

**Diode arrays**
- 8 diode arrays
- 6624 diodes total (900 nm)
- 730 kW peak power (110W/bar)

**Crystals**
- 7 Yb^3+:Sr_5(PO_4)_3F slabs in each amplifier head
At the time of Jeju tests with a single amplifier head had begun

- **At Jeju**
  - Single head operation was begun
- **In summer of 03 single head testing was completed**
  - Redesign of amplifier crystal coating to reduce damage
  - All crystals refabricated
  - Other system improvements made
- **January 04, full system installed**
  - First light in the full system
Crystals need better than standard polishing for damage resistance

- High damage threshold coatings require high quality surfaces
  - Damage in the crystal transfers to the coating and is the site of damage formation
  - Magneto-rheological finishing (MRF) removes sub surface damage

Conventional polish

MRF 2micron removal uncovers subsurface scratches

Further MRF achieves <1nm roughness
The Magnetorheological Finishing (MRF) machine at LLNL is being used to improve the wavefront of Yb:S-FAP slabs.

Deterministic finishing:
- Subaperture polishing “tool”
- Raster
- Optic

Conventional polishing:
- Optic
- Rotating pitch lap
- Weights

The removal function is held constant during polishing and material removal is controlled by varying the residence time over the optical surface.
Reprocessing all amplifier crystals has led to some delay.
We have fabricated and qualified 80 kW diode arrays for a total of 320 kW of peak diode power.

Operated at:
- 120 W/bar at 10 Hz
- 900 ms pulsewidth

Divergence = 1 x 8 degrees

Power droop = 4.3%

Bandwidth = 4 nm
An experimental set-up has been built to observe anomalous, high temperatures that are precursors to diode failures.

- Two “hot” regions identified
- Strong correlation between hot spots and eventual failures

We anticipate the temperature field scan technology will be a useful diagnostic for eliminating weak diode bars and improving process-control.
Many improvements made in preparation for the two-head running

- Improved processing of crystals
  - Higher damage threshold for coatings
  - Better wavefront control, higher extraction efficiency
- Automated monitoring of diode bars
- Pockels cell to prevent spontaneous amplification
- Improved coatings on beamline optics
- Wavefront corrector plates installed in the amplifier heads

- Industrialization, several vendors are looking at
  - Growing Yb:S-FAP crystals, cutting, bonding
  - Producing diode bars

First light is in the system
Full power running this summer