UCRL-MI-140140

NIF Optics

T. Parham

August 30, 2000

U.S. Department of Energy

Lawrence
Livermore
National
Laboratory

This work was performed under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

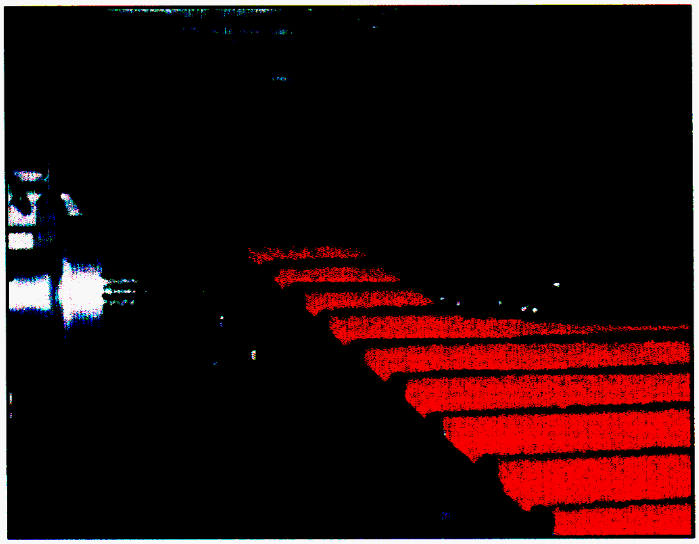
NIF Optics

One of the major highlights of the technology development for the National Ignition Facility (NIF) is the optics. NIF will be the largest laser ever built, requiring 7500 large optics (over one foot across) and more than 30,000 small optics. The design, manufacture, and assembly of these important pieces have called for innovative ways to make optics of higher quality than ever before, and to do so at unprecedented speeds.

The most obvious role of NIF optics is to steer the 192 laser beams through the 700-foot-long building onto a dime-size laser-fusion target. The less obvious optic roles are using *NIF laser glass* to create laser light out of normal light, and using *KDP crystals* to convert that laser light to the correct frequency; both of which are technically challenging requirements. The *Optics Processing Laboratory* and *Optics Assembly Building* enable the final preparation and mounting of these amazing optics for their use in NIF.

NIF Laser Glass

Laser glass is the heart of the NIF laser system; it is the material that generates the laser light. Laser glass contains a chemical additive consisting of atoms of neodymium. The glass is installed in the laser in a metal box and surrounded by a series of flashlamps, which perform in the same way as a flashbulb on a camera. When we are ready to fire the laser, we push a button that discharges the electrical energy from a series of capacitors into the flashlamps, producing an enormous flood of white light. This white light is absorbed by the neodymium atoms in the glass, causing them to become "excited." A weak laser beam then passes through and stimulates all the excited atoms to give up their energy at exactly the same wavelength as the weak beam. This process amplifies the weak beam, making it much stronger.



The NIF laser system uses about 3100 large plates of laser glass. Each glass plate is about three feet long and about half as wide. If stacked end-to-end, the 3100 plates would form a continuous ribbon of glass nearly two miles long. To produce this laser glass, we use a new production method developed by two companies (Hoya Corporation, USA and Schott Glass Technologies, Inc.) that continuously melts and pours the glass. Once cooled, the glass is cut into pieces that are polished to the demanding NIF specifications.

KDP Crystals

NIF's KDP crystals have two uses: frequency conversion and polarization rotation. The development of technology to more quickly grow high-quality crystals was a major undertaking, and is perhaps the most highly publicized technological success of the NIF Project.

Frequency Conversion

NIF laser beams originate with an infrared frequency, but the interaction of the beams with the fusion target is much more favorable if the beams have an ultraviolet frequency. By passing the laser beams through plates cut from large KDP crystals, their frequency is converted to ultraviolet before they strike the target.

Polarization Rotation

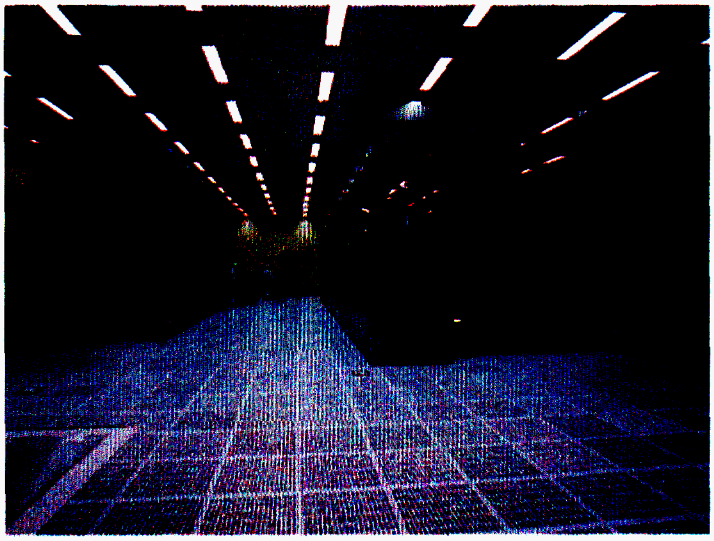
The amplifier section of the NIF's laser beampath has an optical device containing a plate of KDP. This device, in concert with another optic, acts as a switch to let beams in, then rotates its polarization, trapping the laser beams in the amplifier section. It rotates the polarization back after the beams' fourth pass through, letting them escape toward the target chamber.

The KDP Growth Challenge

The rapid-growth process for KDP, developed to keep up with NIF's aggressive construction schedule, is amazingly effective: crystals that would have taken up to two years to grow by traditional techniques now take only two months. In addition, the size of the rapid-growth crystals is large enough that more plates can be cut from each crystal, so a smaller number of crystals can provide NIF with the same amount of KDP.

NIF Optics Assembly

After final surface finishing by outside suppliers, NIF optics undergo precision cleaning and application of special antireflection coatings in the *Optics Processing Laboratory* (OPDL) here at the Livermore Laboratory. Without these coatings, much of the laser's energy would be lost long before it reached the fusion target. The optics are then transferred to the *Optics Assembly Building* (OAB), which is attached to the main NIF laser building on the end opposite the target chamber. The OAB is a clean-room facility where the large optics and mechanical parts are combined into line-replaceable units (LRUs) before being deployed to operating locations within the NIF. The ability of the OAB and the LRU transport vehicles to quickly, safely, and cleanly assemble, test, install, and repair LRUs is a key element of the NIF's ability to perform its demanding experimental duties.



Questions concerning the National Ignition Facility at LLNL should be directed to the LLNL Public Affairs Office, (925) 422-9919.

UCRL-MI-140140
08/21/00