Science & Technology

Rochester inaugurates 24-beam Omega laser

by Charles B. Stevens

In the suburbs of the city of Rochester, along the banks of the Genesee River in upstate New York, scientists at the University of Rochester's Laboratory for Laser Energetics (LLE), direct a concentration of energy more powerful than all other activities in the continental United States, combined. The energy is in the form of 24 laser beams of the Omega laser which can be focused onto a target less than a thousandth of an inch wide. Before hitting the target the laser beams are about a foot long—sometimes shorter pulses, less than an inch long, are used. Because they travel at the speed of light, it takes these powerful beams less than a billionth of a second (a nanosecond) to deposit their energy.

On April 17-19, the full-power Omega was dedicated during a conference on "Laser and Particle Beams for Fusion and Strategic Defense," held at LLE, the leading American laboratory exploring the development of direct drive inertial confinement fusion.

Within a few days, Omega had set the record for the most fusion energy generated by a laser, with more than 1.6 trillion fusion neutrons being measured. The 24-beam Omega puts out more than 12 trillion watts of laser light. Recently it has been converted to the short wavelength, ultraviolet .351 microns—a laser wavelength which is called blue. The advanced laser and optical technology developed at the University of Rochester has allowed the Omega to have among the highest repetition rates in the world for high power lasers: It can be fired every 30 minutes. Other facilities, such as the 130-trillion-watt, 10 beam Nova at Lawrence Livermore National Laboratory in California, generally are capable of only a couple of laser shots per day.

This makes the Omega highly productive for research. Because the federal government has designated LLE as a National Laboratory of the Department of Energy's controlled fusion research effort, and the only National Laser Users Facility, Omega has been made available for research to the entire scientific community, including academic and medical institutions, industry and government laboratories. In fact, LLE is the most powerful and versatile research facility readily available to scientists throughout the world.

At present, only a small portion of the electromagnetic spectrum is being harnessed in industry and scientific research. High-power lasers such as Omega provide both the means and immediate motivation to rapidly extend this. Some graphic examples of this process are as follows.

The picosecond switch: High-power glass lasers, despite their gargantuan outputs measured in trillions of watts, are fragile devices. They are designed, constructed and operated with extreme accuracy. The buildings in which they are housed are super-clean, and reinforced against even the smallest vibrations. Within the bay of the Omega, the atmosphere is kept 100 times cleaner than the cleanest operating room found in the best hospital.

Producing and measuring processes which last less than a billionth of second necessitate operating some elements of the system on much smaller time scales—trillions of a second, or picoseconds. In developing a sub-picosecond switch to control one of Omega's elements, Rochester scientists produced a major advance in computer microchips.

Nanosecond electron microscopes: Currently, electron microscopes have the greatest spacial resolution. Recent advances have brought this resolution down below atomic dimensions of one Angstrom. The use of short laser pulses, makes possible generation of electron beam pulses of short duration. This permits the electron beam pulse not only to image atomic scale processes, but to do so on extremely short time scales. This allows one to examine phase changes in structures like monomolecular layers—thin films, the most essential element to the construction of microchip circuits.

Lasers in angioplasty: Biological and medical research are proving to be the most fertile fields for high-power laser diagnostics. One recent example is angioplasty—removal of plaque in the arteries of the heart with short-wavelength laser beams.

The condition known as hardening of the arteries, or atherosclerosis, consists of blockage of the coronary arteries by plaque. When 80 to 90% of the cross-sectional area of a coronary artery is occluded (blocked), the flow of blood is badly impaired, and the risk of cardiac arrest, and general susceptibility to disease and infection, increases considerably.

At present, this condition can only be treated by major surgery, to restore blood flow in occluded arteries. Arterial bypass surgery is the most commonly performed operation in the U.S. today. The chest and heart itself are opened, to graft bypasses to reroute the blood flow around blockages. Such a procedure is life threatening, and involves a long convalescence.

Rochester is developing techniques whereby a thin glass fiber can be inserted in an artery without major surgery. Intense pulses of laser light can then be used to blow away plaque, without damaging the artery itself. By year's end, this new and much more economical heart treatment should be demonstrated in clinical practice.