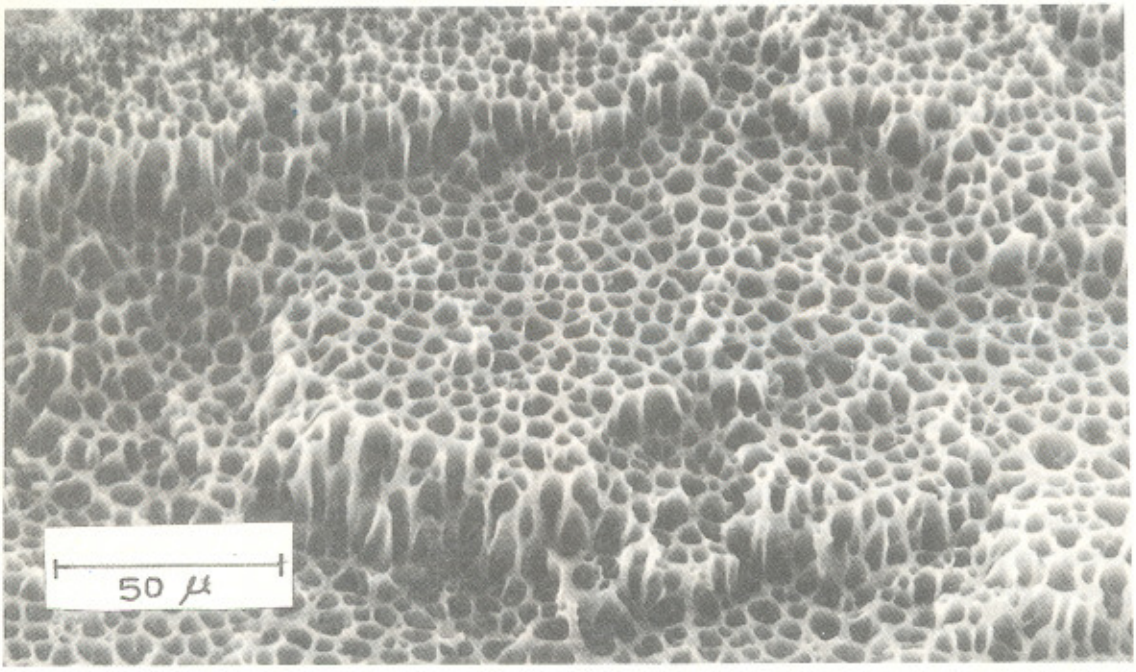
Newsletter

CENTRE FOR ADVANCED TECHNOLOGY

Year - 6 | No. 2 | July - December 1993



RESEARCH AND DEVELOPMENT

LASER PROGRAMME

Nd: Glass laser chain for XUV and soft x-ray generation

A 2 GW, 28 ns/ 7ns Nd:phosphate glass laser chain (λ = 1.054 μm) has been developed for studies of XUV-soft x-ray generation in laser produced plasmas. Nd:doped phosphate glass is chosen as the active medium in view of its higher stimulated emission cross section and a smaller value of the non-linear index of refraction. The laser chain consists of a Q-switched master oscillator and four power amplifiers of successively increasing aperture size, an electro-optic laser pulse slicer, two vacuum spatial filter-cum-image relay systems, a Faraday optical isolator, and a number of beam energy monitoring units. The laser rods in the oscillator and four amplifiers are of dimensions: 5mm dia x 100mm length, 10mm dia x 150 mm length, 15mm dia x 200mm length, 25mm dia x 300mm length, 50mm dia x 300mm length respectively. Since phosphate glass is somewhat hygroscopic, polished end surfaces of all the laser rods are protected in specially designed low humidity enclosures. All the stages are optically pumped using xenon flashlamps. The system operation and monitoring is done entirely using a microprocessor-based control unit.

The Q-switched oscillator provides an output laser pulse of 50 mJ energy in 28 nsec (FWHM) in the TEM_{oo} mode. A double pass laser pulse slicer unit, based on fast switching of the quarter-wave voltage on a KD*P Pockel

Cell using avalanche transistor stacks, provides a laser pulse of 7 ns (FWHM) duration. The operation choice between 28 nsec and 7 nsec pulse durations can be accomplished using a selector switch, without changing the beam path and the alignment.

The output beam from the pulse slicer is magnified using suitable telescopic lens combinations and fed to the amplifiers. Whereas the oscillator uses a double elliptical pump cavity, the first three amplifiers have clover-leaf reflectors and the fourth amplifier has a cylindrical reflector cavity. The cavities are designed so as to provide an optimum combination of high coupling efficiency with uniform pumping in the radial direction. The clover-leaf reflector geometry in the first three amplifiers provides 60% higher efficiency than a cylindrical reflector would. The electropolished aluminum reflectors provide an enhanced effective coupling of the pump radiation to the laser rod about 15% and 25% over those for mechanically polished aluminum reflectors and the gold electroplated cavity respectively.

As the laser beam propagates through the various amplifier stages, its spatial profile develops diffraction rings due to beam aperturing and some inhomogenities present in the medium. Two vacuum spatial filters cum image relay systems are used to remove high frequency spatial noise from the laser beam profile to avoid any possible damage due to self-focussing. These are placed between the 2nd and the 3rd amplifiers, and the 3rd and the 4th amplifiers respectively, and have a cutoff spatial frequency of 5 cm^{-1} with a laser energy transmission of about 75% and about 80% respectively.

A Faraday optical isolator is installed at the end of the laser chain to prevent any laser light, backreflected from the plasma, from propagating backwards through the amplifier chain which could cause extensive damage to the various optical components. This isolator uses an FR-5 glass placed in a solenoid coil producing a pulsed magnetic field of about 15 kG. Its isolation factor has been measured by a probe laser beam to be about 6500 for the back-reflected beam, whereas the transmission of the forward direction laser beam is about 92%.

Studies on laser tissue interaction

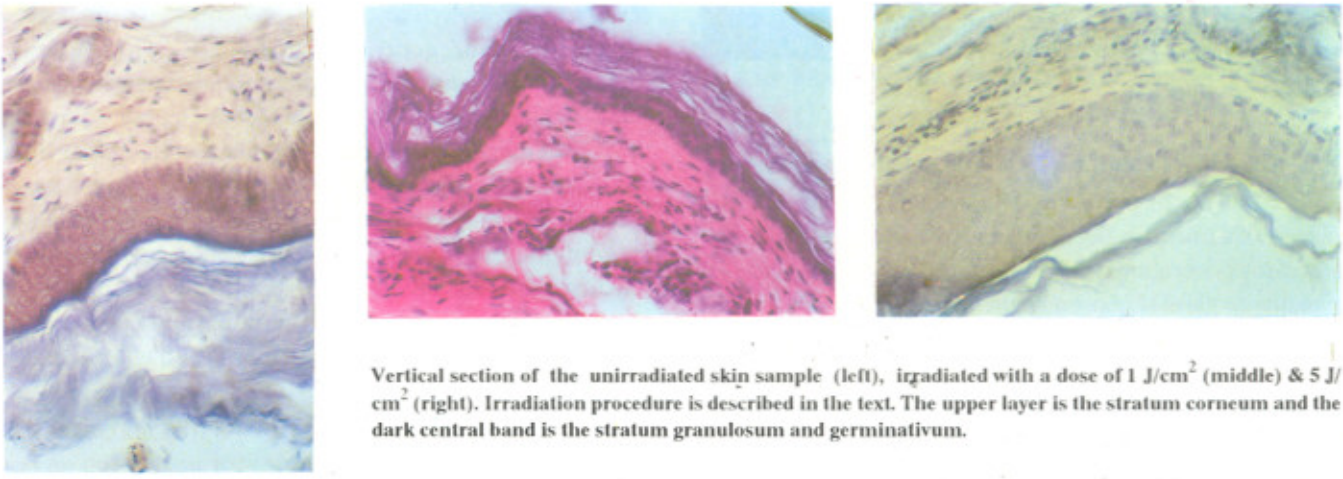
Studies are being carried out to investigate the effect of laser irradiation on animal models/ bacterial systems and on the use of laser induced fluorescence from tissues for discrimination of neo-plastic tissue from normal.

Autofluorescence spectra of malignant and adjoining normal human tissues have been recorded both from intact tissues and from tissue extracts at various excitation wavelengths. The spectra showed significant differences between malignant and normal tissue with respect to the fluorescence yield, bandwidth and spectral intensity distribution. These may be exploited for discrimination of a neo-plastic tissue from a normal one.

Histological studies on the scrotal skin of Indian albino rabbits irradiated with N_2 laser to a dose of 1 J/cm^2 to 5 J/cm^2 for 10 days at 24 hr regular interval showed marked differences in the epidermal area compared to the unirradiated sham. At the lower dose (1 J/cm^2) the stratum corneum was observed to be considerably thinner in the irradiated skin compared to the unirradiated. Further, the total height of the stratum granulosum and stratum germinativum in the irradiated skin was considerably increased and the cells of the stratum germinativum were more active compared to the unirradiated skin. In contrast, at the higher dose (5 J/cm^2), the thickness of active epidermal layers was significantly smaller than both the sham and the 1 J/cm^2 samples, while that of the stratum corneum was intermediate between the two. These observations suggest that the lower dose leads to a proliferation of cells in the stratum germinativum and inhibition occurs at the higher dose used.

Optical limiting in C_{60}

Nonlinear optical response of fullerenes, the recently discovered new form of carbon, is currently being inves-



Vertical section of the unirradiated skin sample (left), irradiated with a dose of 1 J/cm^2 (middle) & 5 J/cm^2 (right). Irradiation procedure is described in the text. The upper layer is the stratum corneum and the dark central band is the stratum granulosum and germinativum.