Newsletter

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RESEARCH AND DEVELOPMENT

LASER PROGRAMME

Laser driven monochromatic point x-ray source

Generation of high spectral brightness x-ray pulses, using high power lasers is desirable for potential applications in x-ray imaging of non-stationary micro-objects, micro-lithography and time resolved x-ray diffraction. Whereas laser heated plasmas emit broad band intense x-rays, a laser driven vacuum diode can provide monochromatic x-ray pulses. An experimental study, of monochromatic x-ray generation in a laser driven vacuum diode using electrons from a laser produced aluminium plasma has been carried out. About 4×10^9 Ti-Kα x-ray photons ($h\upsilon$ = 4.5 keV) per pulse (~16 to 28 ns (FWHM)) are estimated from a source of ~300 micron diameter with a single pulse spectral brightness of ~10^{20} photons/cm^2-sec-Sr-keV.

The diode consists of a planar aluminium slab as cathode and a point tip anode (diameter ≈ 300 μm) of titanium placed in a chamber evacuated to 3×10^{-5} torr. The anode is biased to ~20kV using a DC power supply. Plasma was produced by focussing a laser beam from either a Nd:YAG laser (Energy 2 mJ to 40 mJ, 15 ns (FWHM), 1Hz) or a Nd:glass laser (Energy 2mJ to 4J, 28ns (FWHM), single shot operation). X-ray emission from the anode is measured using filtered pin x-ray diodes for different laser energies and anode-cathode distances. At a fixed value of laser energy, the x-ray intensity is observed to be maximum for an optimum value of anode-cathode distance of ~3 mm. On the other hand, for a fixed value of anode-cathode distance, the Kα x-ray intensity is observed to be practically constant in the laser energy range of ~2mJ to 200mJ. Generation of intense monochromatic x-ray pulses at the small laser energy of few mJ is possible since the laser produced plasma is used only as a source of electrons. This can be important in producing a compact Kα pulse x-ray source. Another advantageous feature of this diode is that the x-ray radiation pulse can be temporally synchronised with the incident laser pulse.

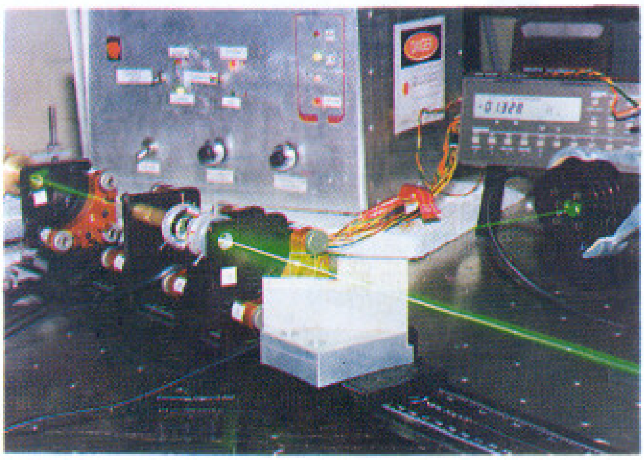
Study of diffraction efficiency of gold microstructure transmission gratings in keV spectral region

X-ray line emission from a laser produced plasma has been used to study diffraction efficiency of a gold microstructure transmission grating in the keV spectral region. Free-standing gold microstructures such as transmission gratings and Fresnel zone plates are being increasingly used as x-ray optical elements in a wide variety of research and applied areas, involving XUV-soft x-ray sources such as synchrotron radiation, laser produced plasmas, z-pinch plasmas etc. These microstructures due to their sub-micron thickness become partially transparent in the soft x-ray region ($h\upsilon \geq 1$ keV) and thus behave like a phase grating. This results in modification in the spatial intensity distribution of the diffracted x-ray radiation.

A high resolution transmission grating spectrograph is set up using a gold microstructure with a grating period 'd' = 0.2 μm and a/d ratio of ~0.42, where 'a' is the free space between the grating bars. The spectrograph parameters are optimised to achieve a spectral resolution of 0.6 Å in the wavelength region 3-90 Å. X-ray source was produced by irradiating a planar magnesium target using 2 GW, 25 ns single laser pulses at intensities of $\sim 4\times10^{12}$ W/cm^2. Relative intensities of the Mg XI, $1s^2$-$1s^2p$ line emission (9.2 Å) in the zeroth to fourth order were measured. The contribution of continuum and line radiation at other wavelengths to the zeroth order was suppressed by using a 6 μm aluminium filter. Ratio of intensities of the first to fourth orders w.r.t. the zeroth order was experimentally determined to be (1.3±0.15), $(1.0\pm0.15)\times10^{-1}$, $(5.9\pm1.2)\times10^{-2}$ and $(4.6\pm2.4)\times10^{-2}$ respectively. It is noted that these experimentally measured ratios are more than two times higher than those expected for longer wavelengths, where the grating bars are totally opaque. The observed diffraction efficiencies are found to be in agreement with theoretical calculations considering the effect of partial x-ray transmission through the gold bars, for the known grating parameters. This increase in first order diffraction efficiency at the expense of the zeroth order has interesting possibility of using such gratings as x-ray optical elements in the keV spectral region, such as beam splitters and beam combiners for setting up a x-ray interferometer.

300mW diode pumped green laser

A semiconductor laser pumped, intracavity doubled, laser giving 300 mW cw power at 532 nm has been developed at CAT. These lasers have important applications in medicine as well as for R & D Labs. The gain medium is a 1 mm thick YVO_4 crystal with 1 atom % doped Nd_3^+ ions. The laser is pumped by a 2.6 W diode laser of wavelength 809 nm, and 5 mm thick type II phase matched KTP crystal is used as the intra cavity doubler. With the intracavity doubler removed, this laser can give 760 mW of IR power at 1064 nm (with an output coupler).



300mW diode pumped green laser developed at CAT

ACCELERATOR PROGRAMME

Mapping power supply for quadrupole magnets

A power supply for mapping of Indus-2 quadrupole magnets is developed using the high-frequency resonant power processing technique. Resonant converters have become very attractive for power conversion, due to numerous advantages such as elimination of switching loss, low switching transients, reduced EMI, small size and use of loss-less snubbers.

The main part of the power supply is the variable-frequency square-wave inverter and resonant network that transfers and controls the fundamental power to the output in a piece-wise sinusoidal manner. Overall performance of the power supply depends upon the design and optimisation of resonant network. There are multiple constraints for the optimisation,

Specifications of Mapping Power Supply for Indus-2 Quadrupole Magnets	
Input Supply	Three-phase , 415V±10% , 50Hz
Max. output voltage	60V
Max. output current	170A
Min. output current	22A
Current stability (Including drift and ripple)	± 50ppm
Operating frequency	20 to 50 kHz
Control loop bandwidth	3.5 kHz
Efficiency	89.5 % maximum
Cooling	Forced air