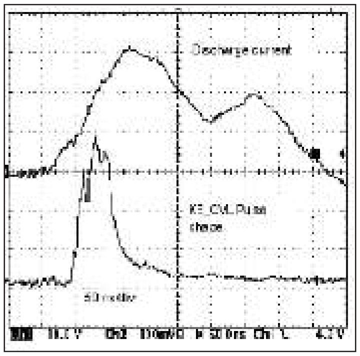

Fig. L.2.2 *Discharge current and laser pulse shapes*

performance dramatically. We have successfully demonstrated an indigenous kinetically–enhanced CVL system with 60-65 Watt power, based on these concepts and parameters. The laser was operated at ~ 9-10 kHz rep-rate at a total input power of about 5 kW with an overall electro-optic efficiency of about 1.25%. The laser output power buildup with time is fast and efficient as shown in fig.L.2.1. Also, the high efficiency of the CVL is maintained at low input power level of ~ 3kW. This gives an added option of operating the KE- CVL at low input power efficiently as per the need and application of the CVL beam. The KE-CVL pulses are longer in duration by 25% with better beam quality as compared to normal standard CVLs (fig.L.2.2)

(Contributed by: Bijendra Singh; bsingh@cat.ernet.in)

L.3 Depth resolved fluorescence measurement in layered turbid medium by polarized fluorescence spectroscopy

For epithelial tissue, it has been shown that the contrast in auto-fluorescence from malignant and nonmalignant sites depends strongly on the difference in depth distribution of endogenous fluorophores [Drezek et al, Photochem. Photobiol., 73, 636-641, 2001]. Therefore, depth resolved fluorescence measurements, which can decouple the epithelial and stromal (connective tissue) fluorescence, would help maximize the contrast between malignant and nonmalignant tissue sites and thus improve diagnosis. We have demonstrated that measurement of fluorescence polarized at different angles with respect to the linearly polarized excitation can be used to probe fluorophores located at different depths inside tissue. This arises because the fluorescence emitted from deeper layers of tissue gets more depolarized due to multiple scattering compared to that emitted from superficial layers.

The applicability of this approach was demonstrated using a two-layered tissue phantoms and resected tissue samples. The samples were illuminated by linearly polarized light (λ_{ex} = 440 nm) from a 450 Watt xenon lamp and polarized fluorescence spectra [$I^{fl}(\Delta\theta, \lambda)$] were recorded for varying angles ($\Delta\theta$) between the polarization axes of the analyzer with respect to the excitation polarizer. A synchronous scan with zero offset between the excitation and the emission monochromators was used to record polarized elastic scattering spectra [$I^{es}(\Delta\theta, \lambda)$].

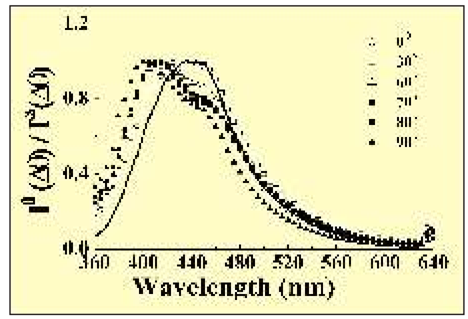

Fig. L.3.1 *Dependence on $\Delta\theta$ of the 340 nm excited elastic scattering normalized fluorescence spectra [$I_n^{fl}(\Delta\theta, \lambda) = I^{fl}(\Delta\theta, \lambda) / I^{es}(\Delta\theta, \lambda)$] from mice oral tissue sample.*

In fig.L.3.1, the dependence on $\Delta\theta$ of the 340 nm excited fluorescence spectra [$I_n^{fl}(\Delta\theta, \lambda)$] from an epithelial tissue resected from oral cavity of mice is displayed. In order to compensate for wavelength dependent propagation losses in fluorescence coming from deeper layers, the fluorescence was normalized with respect to the elastic scattering spectra [$I^{es}(\Delta\theta, \lambda)$] recorded under the same conditions. The difference spectra [$I_n^{fl}(\Delta\theta = 0^o, \lambda) - I_n^{fl}(\Delta\theta = 90^o, \lambda)$, displayed by solid line] and the normalized fluorescence spectra at smaller $\Delta\theta$ values ($\Delta\theta$= 0°, 30°) shows prominent peak around 440 nm that is a characteristic signature of NADH present in the superficial epithelial layer of tissue. Spectra recorded at larger $\Delta\theta$ show a prominent peak at ~ 400 nm that represents collagen and elastin present in the deeper connective tissue layer. [For more details: *N. Ghosh, S. K. Majumder, H. S. Patel and P. K. Gupta, Optics Letters, to appear in 30 (2005)*].

(Contributed by: N Ghosh, S K Majumder, H.S Patel, P K Gupta; pkgupta@cat.ernet.in)

L.4 X-ray bolometer for studies of laser produced plasmas

Absolute quantitative measurements of broad band (10 eV < $h\nu$ < 5 keV) X-ray fluence from pulsed plasma sources such as laser produced plasmas, Z-pinch plasmas etc. play an important role in using intense X-ray emission from these plasmas for applications in the indirect inertial confinement fusion scheme, development of soft X-ray lasers, soft X-ray imaging of live biological specimen, and X-ray lithography. X-ray bolometer is one such device widely used for absolute flux measurements from pulsed X-ray sources. It is essentially a radiation detector, which exploits the change of electrical resistance of a metallic microstructure due to rise in temperature caused by X-ray absorption. Broadly there are two types of bolometers depending on whether the microstructure is directly exposed to the incident radiation or otherwise. While the directly exposed bolometers have a higher sensitivity, they suffer from the noise generated by resistance shunting due to secondary electron emission by the incident radiation and exposure of the microstructure to the plasma debris. Hence indirect type of bolometers, in which the microstructure resistance receives heat from the absorber element through an insulating foil, are more suitable for pulsed plasma sources. We have developed this type of X-ray bolometer in collaboration with Space Application Centre, Ahmedabad, and used it for measurements of intense X-ray radiation emitted from laser-produced plasmas.

Bolometer basically consists of three elements: 1) radiation absorber, 2) microstructure, and 3) balanced bridge circuit. A schematic of the detector element is shown in fig.L.4.1. The absorber layer and the microstructure are created on the opposite sides of a 8μm thick Kapton foil (25mm x 25mm) which serves as the insulator layer. The production of gold microstructure, comprising of a meander pattern of 15 μm line width spaced at 50μm of a total length of ~ 38cm, involved several critical steps. After cleaning the foil by glow discharge, a thin layer of chromium of 100 nm thickness was coated on a central area of 7mm x 7mm. This was followed by deposition of 0.2 μm thick gold layer on both the sides of the foil using an RF sputtering system. Then, using standard photo-lithography technique, a meander resistor pattern of a line width of 15 μm spaced at 50 μm was transferred onto the positive resist coated Kapton foil on one side through a corresponding glass mask. Since wet processes were not suitable for handling such thin foils, the pattern delineation was carried out using a dry etching process viz. ion beam milling, which provides almost zero undercut profiles of the pattern. A meander pattern area of 5 x 5mm^2 was achieved with a resistance value of 6.68kΩ. Next, the thickness of the gold absorber layer on the front side of the Kapton foil was increased to ~ 4μm by standard pulsed electroplating technique. Finally, the resistance pattern connecting pads were glued using conducting epoxy with two thin copper wires for electrical connections. These wires were then soldered to a BNC connector mounted on a metallic housing (overall size 40 x 80 x 100mm^3) enclosing the bolometer structure (fig.4.L.2). The absorber layer at the front of the bolometer was thermally shielded from the metallic housing. This prevents any lateral heat conduction from the gold absorber foil to the housing, and therefore results in error-free measurement of the X-ray flux. Further, since there is no loss of heat due to lateral heat conduction from the foil, the cooling time constant of the bolometer is high (~ 5 seconds).

The bolometer was characterized using X-rays (hν > 0.8keV) from laser produced copper plasma and calibrated with the help of standard XUV p-i-n diodes of known response. The change in the microstructure resistance was detected by a simple balanced bridge circuit, followed by a low drift low offset and high stable gain commercial differential amplifier with a gain of 1000.

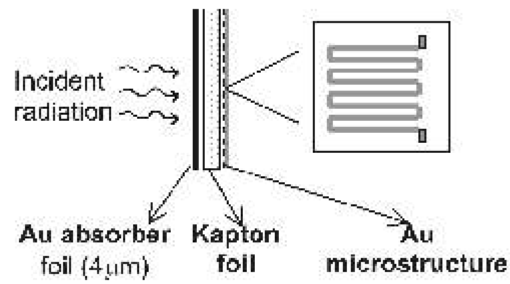

***Fig. L.4.1** Schematic of X-ray bolometer detector*

***Fig L.4.2** Bolometer detector assembled in the metallic housing*

The response of the bolometer was found to be 1.23mV/mJ and is linear over a wide range of incident X-ray flux. The bolometer is suitable for broadband x-ray flux measurement from 10eV to 5keV energy range, and is being used for studies of laser-produced plasmas.

(Contributed by: J.A. Chakera, (chakera@cat.ernet.in) and P.A. Naik)

L.5 Intense x-ray emission from moderate-current low-energy laser-triggered vacuum discharge

Low inductance vacuum spark discharge initiated by laser pulses or electrical trigger is an attractive X-ray source of energy ranging from a few keV to few hundred keV. Hard X-ray emission from these devices (which typically involve discharging a capacitor of 20-30μF, charged to 10-20kV with