vicinity of three times the critical density. To corroborate this hypothesis, the spectral shift of the laser light transmitted through argon cluster plasma was also studied. The transmitted laser light spectrum also showed blue shift only with some unshifted laser light (see fig. L.7.2). The blue shift was found to be consistent with the one observed in the side scattered light. This blue shift may be useful as a diagnostics for understanding the resonant interaction phase of laser-cluster interaction.

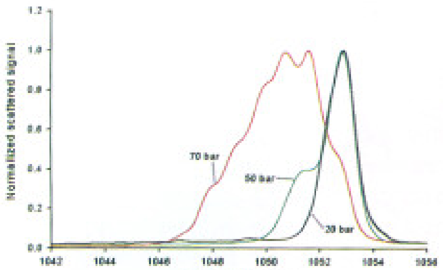

Fig. L.7.1 Normalized spectra of scattered laser light from argon cluster plasma at different backing pressures

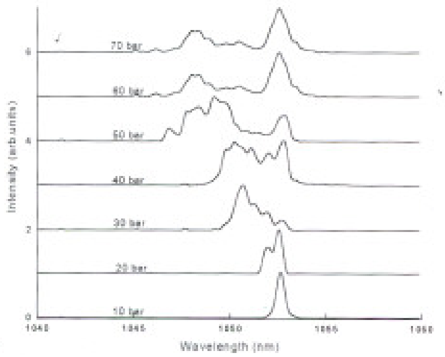

Fig. L.7.2 Spectrum of the light transmitted through the cluster plasma at different backing pressures

In addition, relative x-ray emission from nitrogen and argon gas clusters was also studied. High absorption of ~ 80% to 85% was observed for both the gases for pressures exceeding 35 bar. However, it was found that the x-ray line emission from argon clusters was about 40 times higher than in nitrogen clusters. This is explained to be due to formation of larger size clusters in the argon gas, which, after heating, take a longer time to expand and cool. [For details see : *S. Sailaja, R. A. Khan, P. A. Naik and P. D. Gupta, IEEE Transactions in Plasma Science 33, 1006, June 2005*].

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L.8 Setting up of an optical coating plant and some results

Thin film optical coatings play an important role in many areas of R&D. Coatings do have a shelf life and it is advisable not to stock them for long. The solution to these problems is to have a facility where various types of optical coatings as per the requirement can be carried out. We have installed a state of the art optical coating plant. The basic system was fabricated, assembled and computer automated by M/s Elettrorava, Italy as per our design and requirement. It is basically an ion-assisted electron beam and sputter deposition system for multilayer optical coatings. The system is equipped with two electron beam guns (each 10kW), two resistively heated sources (each 3 kW), two sputtering sources (one 600 W RF and one 1.5 kW DC) and one ion gun (40 – 210 eV, 0 – 1 A) with selection of the gas (O_2 and/or Ar) for ion-assisted deposition. Substrate rotation up to 30 rpm and heating up to 350 °C is possible during deposition. In-situ optical thickness monitor operating in both transmission and reflection modes in the wavelength range 300 to 1700 nm and quartz thickness monitors are used for layer termination. Glow discharge cleaning of the substrate can be carried out prior to deposition.

In a single evaporation run, 40 nos. each of 50 mm diameter and 60 nos. each of 25 mm dia. or 9 nos. each of 150 mm dia. or one substrate of 400 mm dia. can be coated. Very high thickness uniformity of ±5% is routinely attained on large size substrates. Simultaneous evaporation or simultaneous sputter deposition of multiple dielectric materials and metals are possible in the system. Substrate rotation during sputtering results in very high thickness uniformity (< 2%) on 150 mm diameter substrates. Fig. L.8.1 shows the view of the coating unit. The system can be utilized for large variety of dielectric and metallic coatings, e.g. antireflection coatings, highly reflecting coatings (dielectric and metal), broad band pass (>30 nm) and narrow band pass (<30 nm) filters, edge filters, beam splitters, neutral density filters, polarising coatings. A thin film characterization laboratory with the following instruments has also been developed:

1.Spectrophotometers: VARIAN CARY5000; Wavelength: 175-3300nm, Modes: Transmittance, specular reflectance, variable angle specular reflectance, diffuse reflectance and absorbance; VARIAN CARY50: Wavelength: 190-1100nm, fibre optic attachments for transmittance and specular reflectance measurements. 2. Abrasion Testing Kit: As per US MIL standards of abrasion, hardness and adhesion. 3. Scanning Probe Microscope (NT-MDT SOLVER PRO): Non-contact, contact, etc. 4. Variable angle spectroscopic ellipsometer (SOPRA): Wavelength: 240-1700nm, Angle of incidence: 20-90°, Modes: ellipsometry (n, k & d) and inhomogeneity.

Fig. L.8.1 View of the deposition system.

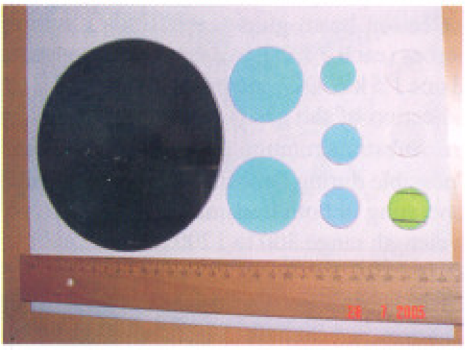

Fig. L.8.2 View of some of the coatings made.

Coatings were done are: (i) AR coatings on lenses used for coupling a Nd:YAG laser into optical fibre, (ii) Specialized AR coatings on the end faces of Nd:YAG laser rods. These coatings were found to be hard and withstood laser fluence of 1.2 GW/cm^2, (iii) Gold coating on Si wafer with rms roughness less than 1nm for Indus-1 beam line, (iv) Very thick gold coating on Al foils of different thickness to be used as targets for laser produced plasma experiments, (v) Aluminium coating on 100mm dia. glass samples for Spectroscopy Div., BARC, (vi) Thick Ti coating on 240 mm diameter copper disc is being developed for IGCAR. Fig. L.8.2 shows the view of a few coated elements.

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L.9 Advancement in sealed-off nitrogen laser system and uranium analyzer

A compact sealed-off nitrogen laser module with a life of more than a year has been developed, which is suitable for field applications. A setup for laser tube assembly and processing facility has been established for vacuum processing the metal-ceramic laser tube before filling and sealing. The laser tube is connected to the vacuum system via a glass-to-metal seal. A double stage liquid-nitrogen trap is incorporated between the vacuum system and the laser tube. This ensures that the volatile impurities such as water vapor and carbon dioxide can be trapped from the filling nitrogen gas, which is detrimental to the laser tube lifetime. The tubes are baked till all out-gassing ceases and then filled with Iolar (grade-I) nitrogen gas. They are run for a sufficient time till the output power stabilizes, then refilled with fresh gas and sealed. Such laser tubes are operated at an underrated voltage of 6 kV for reliability, and produce 30μJ pulses at 10 Hz repetition rate. The Nitrogen laser module has a size of 145 x 75 x 50 mm, works on 12V DC and is an important import substitute.

Fig. L.9.1 The compact version of the Laser Uranium Analyzer

An ultra compact version of laser uranium analyzer has also been developed using the above mentioned compact nitrogen laser tube (fig. L.9.1). Its detection sensitivity ranges from 0.01ppb to 20ppb and requires only 6 W power. It uses a miniature spark gap operating on 12V, SMD based electronics for data acquisition and processing, a compact detector module with a miniature PMT and power supply using SMD components. This is an important import substitute. Three such systems have been assembled and are undergoing test and calibration. Twenty systems are being engineered for various users in DAE, for use in uranium mining, radio chemistry, effluent monitoring & health physics applications.

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L.10 Compact density measurement station

Compact density measurement station has been developed for the metrology of sintered uranium oxide fuel pellets for Nuclear Fuel Complex (NFC) (fig.L10.1). This is designed around a multiplexed optical system to reduce the electronic complexity. A single scanner is used to generate the scans using a multiplexing prism as well as electronics implemented in CPLD to make the instrument compact and reliable.