S.P.28. RADHAKRISHNAN, P.–Nd: Glass laser-induced damage to thin films, two-photon excited fluorescence and plasma studies–1986–Dr. K. Sathianandan.

Laser-induced damage is the principal limiting constraint in the design and operation of high-power laser systems used in fusion and other high-energy laser applications. Therefore, an understanding of the mechanisms which cause the radiation damage to the components employed in building a laser and a knowledge of the damage threshold of these materials are of great importance in designing a laser system and to operate it without appreciable degradation in performance. This thesis, even though covers three distinct problems for investigations using a dye Q-switched multimode Nd:glass laser operating at 1062 nm and emitting 25 ns (FWHM) pulses, lays its main thrust on damage threshold studies on thin films. Using the same glass laser two-photon excited fluorescence in rhodamine 6G and generation and characterisation of a carbon plasma have also been carried out.

The only practical method to determine the most appropriate model of damage in dielectrics is to examine the predictive ability in describing the variation of damage with easily controlled experimental or material variables such as laser pulse width, wavelength and film properties. But in the present experimental investigations, wavelength and pulse width were maintained constant. Analysis of damage has been mainly carried out as a function of the film properties such as refractive index, absorption and thickness. An inverse dependence on absorption and film thickness observed for Spray Pyrolisis Deposited (SPD) and radio frequency (rf) sputtered films in the present investigation gives firm support to the impurity damage model. In the case of damage to transparent polymers the

viscoelastic properties play a dominant role.

A comparative analysis of the damage threshold measurements carried out in transparent-conductive coatings have established that spray pyrolysis deposited tin oxide films are also equally good competitors with rf sputtered indium tin oxide films and chemical vapour deposited tin oxide films in high power laser systems as electrodes for electro-optic shutters. Spray pyrolysis technique offers the added advantage of greater flexibility in terms of their electrical and optical characteristics depending on the deposition parameters which in turn depends on damage threshold.

A noteworthy feature of this thesis is the identification of polyacrilonitrile (PAN) films of high damage threshold (26 J/cm^2) with very low-level absorption at 1060 nm. Another interesting feature associated with these films is that the damage threshold of these films increases with increase in thickness unlike in the case of dielectrics. This makes these films very good candidates for high energy laser applications.

Various types of attempts are being made to increase the threshold of AR coatings since they are the weakest link in any high power laser system. In the present investigation the threshold of a half-wave layer of Mg F_2 films has been shown to increase by about 50% when PAN film having a high threshold was given as an undercoat. The result obtained has been attributed to the change in the chemical environment and to better adhesion of the MG F_2 films on PAN.

In the case of investigation on Mg F_2 films, the threshold is shown to decrease with increase in film thickness as reported by earlier workers. Low damage threshold obtained in the case of gold films has been explained in terms of the low yeild stress of the material and its high absorptance at 1060 nm. Gold coating with an undercoat of PAN does not show any variation in the damage threshold value which is attributed to the poor adhesion of gold on PAN.

Another important result that has emerged out of the present investigations is the determination of the concentration limit of two-photon excited fluorescence in rhodamine 6G.