Chapter 7

Summary and conclusions

Abstract

A summary of the work presented in this thesis is given in this chapter. General conclusions arrived at and the future scope of experiments in this field are presented.
The photoacoustic investigations carried out on different photonic materials are presented in this thesis. Photonic materials selected for the investigation are tape cast ceramics, multilayer dielectric coatings, organic dye doped PVA films and PMMA matrix doped with dye mixtures. The studies are performed by the measurement of photoacoustic signal generated as a result of modulated cw laser irradiation of samples. The gas-microphone scheme is employed for the detection of photoacoustic signal. The different measurements reported here reveal the adaptability and utility of the PA technique for the characterization of photonic materials.

Ceramics find applications in the field of microelectronics industry. Tape cast ceramics are the building blocks of many electronic components and certain ceramic tapes are used as thermal barriers. The thermal parameters of these tapes will not be the same as that of thin films of the same materials. Parameters are influenced by the presence of foreign bodies in the matrix and the sample preparation technique. Measurements are done on ceramic tapes of Zirconia, Zirconia-Alumina combination, barium titanate, barium tin titanate, silicon carbide, lead zirconate titanate(PZT) and lead magnesium niobate titanate(PMNPT). Various configurations viz. heat reflection geometry and heat transmission geometry of the photoacoustic technique have been used for the evaluation of different thermal parameters of the sample. Heat reflection geometry of the PA cell has been used for the evaluation of thermal effusivity and heat transmission geometry has been made use of in the evaluation of thermal diffusivity. From the thermal diffusivity and thermal effusivity values, thermal conductivity is also calculated. The calculated values are nearly the same as the values reported
for pure materials. This shows the feasibility of photoacoustic technique for the thermal characterization of ceramic tapes.

Organic dyes find applications as holographic recording medium and as active media for laser operations. Knowledge of the photochemical stability of the material is essential if it has to be used for any of these applications. Mixing one dye with another can change the properties of the resulting system. Through careful mixing of the dyes in appropriate proportions and incorporating them in polymer matrices, media of required stability can be prepared. Investigations are carried out on Rhodamine 6G-Rhodamine B mixture doped PMMA samples. Addition of RhB in small amounts is found to stabilize Rh6G against photodegradation and addition of Rh6G into RhB increases the photosensitivity of the latter. The PA technique has been successfully employed for the monitoring of dye mixture doped PMMA sample. The same technique has been used for the monitoring of photodegradation of a laser dye, cresyl violet doped polyvinyl alcohol also.

Another important application of photoacoustic technique is in non-destructive evaluation of layered samples. Depth profiling capability of PA technique has been used for the non-destructive testing of multilayer dielectric films, which are highly reflecting in the wavelength range selected for investigations. Even though calculation of thickness of the film is not possible, number of layers present in the system can be found out using PA technique. The phase plot has clear step like discontinuities, the number of which coincides with the number of layers present in the multilayer stack. This shows the sensitivity of PA signal phase to boundaries in a layered structure. This aspect of PA signal can be utilized in non-destructive depth
profiling of reflecting samples and for the identification of defects in layered structures.

In general, the versatility and utility of photoacoustic technique for the evaluation of thermal and physical properties of certain photonic materials like ceramic tapes, dye doped polymer samples and multilayer reflecting coatings, has been experimentally demonstrated.

Scope for future studies:
There are different areas where further investigations can be carried out. Some of them are:
1. The effect of electric field on the thermal parameters of ceramic tapes has not been investigated. As these materials are used in the preparation of microelectronic components, knowledge of the electric field effect will be an added advantage.
2. The theory of photoacoustic signal generation in dielectric multilayer coatings has not been developed.
3. Development of dye doped polymer matrices is an active area where investigations can still be carried out.