# Summary

Interaction of laser energy with material has been a subject of great interest for various applications e.g. in fundamental research, industries (laser materials processing units) as well as defence point of view. Interaction of laser with metals and metal alloys has been studied in past and still in progress. Laser induced damage is very well known phenomenon in metals and laser induced damage thresholds (LIDT) have been calculated for various metals under various set of conditions. In recent years, the use of polymer composite materials, in various industries and also in defence has increased enormously. The effect of heat loading using the conventional heat source on various mechanical and thermal properties on composite materials has been studied in vast. However, little exists in the literature on the CW high energy laser induced effect on metallic alloys as well as composite materials. Many high energy laser effects on composite materials are unknown. Thus investigating these areas are very important in order to estimate the damage caused by various powerful CW laser sources for variety of applications.

In the present research work, we have undertaken very exciting work on high energy laser ($CO_2$ laser ~10.6μm and COIL ~1.3μm) interaction studies with various materials and its structural damage assessments and characterizations. The structural damage assessments of these type of materials will be useful in various applications where these materials are being used in structural part of the system and have to interact with laser. Laser irradiation has been done on the samples by varying the laser and target parameters like time of exposure, power density, thickness and physical conditions of materials. Damage analysis of various metallic alloys and composite materials have been undertaken. The various characterization techniques have been used for assessing the thermal, mechanical and chemical changes in these materials before and after damage. Various shape of the metallic targets have also been considered in present work. The experimental data have been validated with numerical results. A chapter-wise summary is given below :

Chapter 1 includes the introduction and the selection of problem. Chapter 2 links a wide background of laser matter interaction field, various dependent parameters of

absorption coefficient for metal, criteria for high energy laser selection and basic informations about composites. In chapter 3, we have described the detailed account of numerical calculations on physical process of LMI phenomena. A software has been developed using Visual Basic $C^{++}$ platform to find out the various physical process of interaction phenomena and damage analysis. The thermal behaviours of the laser irradiated materials have been studied numerically using COSMOS software and experimental results have been validated with numerical results. The experimental set-up and various characterization techniques that have been used in the research are given here. In chapter 4, the damage trends of various metallic alloys at varying laser parameters have been analyzed using 1.5 kW transverse flow $CO_2$ laser. Chapter 5, deals with the thermal degradation studies of various composite materials using 100W waveguide $CO_2$ laser. The chapter 6 described three different type of work using high mass flow Gas Dynamic laser (10.6μm), viz. the numerical and experimental studies of the behavior of an array of metallic target, the theoretical and experimental investigation of damage effects of a pressurized hollow metal target, then the interaction of carbon based epoxy composite materials and damage assessment through various characterization techniques. Chapter 7 gives laser matter interaction studies on metal as well as composite using COIL beam (1.3μm). Damage analysis of epoxy resin, carbon and glass based polymer composite materials have been undertaken. A comparison between GDL and COIL beam irradiation effects on the carbon based composite is presented here. Chapter 7 summarizes the results of the work presented in the thesis with conclusions.