Chapter 7

Conclusion
The main objectives of the thesis were to modify the ECR plasma system for the complete plasma diagnostics and to map the plasma properties, primarily, for material-processing and to simulate the plasma conditions similar to one existing during the re-entry of space vehicle and also to address the related problems. Another issue addressed in the thesis includes the design and development of Dielectric Barrier Discharge (DBD) based atmospheric pressure non-thermal plasma devices for suitable applications. It is needless to say here that both the kinds of cold plasma devices were successfully designed, developed and tested in varieties of laboratory based applications to their maximum capacity.

The chapter three provides an in-depth analysis of ECR plasma system in terms of its development in the laboratory. The empirical design and dimensions of the ECR plasma system have been presented in view of keeping an audit of the development. The plasma diagnostics of ECR reaction chamber in terms of the variation in the electron temperature and the plasma density have been investigated. The presence of different species has been identified with the help of OES as well as residual gas analysis. The axial and radial distribution of electron temperature in the reaction chamber for different gaseous plasmas has been presented. Hence complete characterization of the reaction chamber has been carried out suggesting the optimum parameters for material processing.

Chapter four includes the utilization of these optimized parameters for different applications. The first application studied was, a nano-crystalline thin film of Fe doped TiO$_2$, deposited by ECR plasma assisted PE-MOCVD technique. These thin films show strong adhesive and re-usable photocatalyst properties for degrading the organic pollutants mixed and dissolved in water. A doping concentration of 2% was optimized for achieving a reasonably high photocatalytic activity. Fe acts as a trapping site which was revealed from the excitonic bands appearing in PL spectra. This helped in enhancing the degradation efficiency of photocatalytic activity.

One of the applications of ECR plasma included, study of effect of oxygen plasma on the solar energy conversion performance of porous ZnO based dye sensitized solar cells. It was observed that oxygen plasma treatment and the duration of treatment plays an important role on the dark and illuminated current-voltage (I-V) characteristics. Therefore effect of different plasma parameters on the I-V characteristic of the solar cell has been investigated. It is observed
that for the optimized conditions of 15 min. treatment of oxygen plasma, efficiency of solar cell enhances.

ECR plasma has also been utilized for the study of interaction of plasma species with thermal protecting system material used in space vehicle. In this investigation, various plasma species such as O, O*, O₂, etc have been generated. These plasma species are responsible for the interaction with the surface of space vehicle during its reentry. It is observed that density of the plasma species as well as temperature of the species possible to vary by varying plasma parameters. Thermal protecting system (TPS) tiles procured from the Indian Space Research Organization (ISRO) India under the collaborative project, has been exposed to oxygen plasma and interactions with reactive oxygen species have been investigated. The wall catalycity of the coated surface was sufficiently high.

Also the epoxy is exposed to oxygen plasma and its interaction has been studied with reactive oxygen species. It is found from the experimentation that, interaction of ECR plasma with epoxy at room temperature does not damage the epoxy surface to large extent, however; heating the epoxy by external agency in presence of oxygen plasma causes its dissociation which was detected in emission spectra. It was observed that, the atomic oxygen recombines on the surface of the epoxy, causing epoxy to heat and evaporate.

Atmospheric plasma devices were developed for the first time in the laboratory and were successfully utilized for different applications. These included: cylinder-cylinder geometry and torch geometry. The cylindrical device can easily fit into the exhaust of the vehicle and has sufficient clearance to keep the flow of the exhaust gas.

The second optimized geometry was the wire plate geometry leading to a plasma torch device. This was indigenously developed for water purification and endodontic treatment applications

Chapter six thus includes the results of utilization of DBD plasma devices for different applications like; this device was employed to disinfect the bacteria present in the tooth cavities which were cultured in laboratory. They included bacteria like *S. aures, B. subtilis, E. coli* and most importantly *E. faecalis* as well as their biofilms. The plasma was seen to be more effective than the traditional disinfectant.
Study of air pollution control was the third application of the DBD plasma devices. For this purpose cylinder-cylinder geometry device was used. This device was indigenously designed to fit in the road vehicle exhausts and was tested for carbon soot and NOx removal.

The thesis provides a thorough background of the cold plasma devices which have wide scope for applied research. They will certainly be useful in future for research in the area of “Plasma Science and Technology”, to be carried out in the Department of Physics in this University.