of carbon carbon double bonds in the polymeric matrix as result of argon ion irradiation. The significant increase in reflectivity and refractive index with increase in ion fluence from $1 \times 10^{16}$ ions cm$^{-2}$ to $5 \times 10^{16}$ ions cm$^{-2}$ is due to creation of sufficient conjugated species below the PET surface [25].

- The refractive index with respect to wavelength at different fluences at varying oblique incidences have been plotted and observed to increase after oblique argon ion irradiation.

### 4.3 Conclusions

The main conclusions drawn from the present studies are as follow:

- Low energy argon ion induced surface rippling in polymeric surfaces using oblique incidences have been reported for the first time to the best of our knowledge.

- Morphological evolution and structural changes as an effect of low energy Ar$^+$ irradiation in PP, PC and PET polymers has been observed using AFM, Raman, UV-Visible spectroscopy and RBS techniques.

- Oblique argon ion beam irradiation in PP surfaces resulted in formation of ripple like features at lower incidences which slowly transforms into dot like structures with increase in ion incidence.

- Raman studies investigated that the fundamental structure of PP specimen has been modified completely after argon ion irradiation and with increase in ion fluence from $1 \times 10^{16}$ ions cm$^{-2}$ to $5 \times 10^{16}$ ions cm$^{-2}$ a asymmetric broadband feature appeared in the Raman spectra at all incidences; containing disordered ‘D’ and graphitic ‘G’ bands.

- RBS studies show an increment in the carbon concentration for all the Ar$^+$ implanted specimens. It has been found that after argon ion irradiation the carbon and argon concentration decreases in the PP specimens with increase in off normal incidence from 30° to 50° at ion fluence of $5 \times 10^{16}$ Ar$^+$ cm$^{-2}$.

- The optical transmission has been observed to decline drastically in PP specimens after argon beam irradiation.
The specular reflectivity of PP specimens has been observed to increase drastically after argon ion irradiation. Further increase in the specular reflectivity with increase in ion fluence from \(1 \times 10^{16}\) ions cm\(^{-2}\) to \(5 \times 10^{16}\) ions cm\(^{-2}\) and oblique incidence from 30° to 50° reflectivity has been observed.

The refractive index has been found to increase in irradiated PP specimens with increase in argon ion fluence and oblique incidences as an effect of argon ion irradiation.

It has been observed that with increase in ion incidence, B-H coefficients i.e. \(\Gamma_y\) approached to \(\Gamma_x\) and elucidated the conversion of ripple morphology into nano-dot morphology in irradiated PP polymer.

The observed slope of Power spectral density (PSD) spectra at 30° oblique incidence and at various ion fluences revealed \(K^{-2}\) dependence which is characteristic behavior value of ballistic drift induced smoothing mechanism. While PSD slope at higher incidences (i.e. at 40° & 50°) has been observed to be of \(K^{-4}\) dependence which indicates the dominance of effective ion-induced surface diffusion (ESD) in irradiated PP samples.

Oblique ion beam irradiation resulted in evolution of nano dot like structures only for a few combinations of ion incidence angle & ion fluence ruling out the possibility of ripple features over PC specimens.

It has been observed that most of the fundamental bands got diminish as a result of argon ion irradiation in PC specimens. The effect has been observed to be more pronounced at higher ion fluences. Further at 30° oblique incidence disorder D and graphitic G band have appeared. The disordering parameter in term of intensity ratio of D & G bands decreased with increase in ion fluence.

The shift in carbon & oxygen edge to the higher channel number w.r.t. ion incidence has been found using RBS studies. Also, argon peak position has been found to be shifted to higher channel number with increase in oblique ion incidence.
The transmission has been observed to decline with decrease in oblique incidences in irradiated PC samples. The increase in ion fluence resulted in further decline in transmission.

The specular reflectivity has been observed to increase in PC samples after argon ion irradiation. The radical enhancement in reflectivity has been observed with increase in ion fluence from $1 \times 10^{16}$ ions cm$^{-2}$ to $5 \times 10^{16}$ ions cm$^{-2}$.

The refractive index has been observed to increase in PC samples after argon ion irradiation with corresponding increase in argon ion fluence and oblique incidences.

B-H coefficients $\Gamma$, & $\gamma$, in case of PC approach each other with increase in oblique incidence. Hence it has been investigated that present experimental conditions ruled out the emergence of ripple like patterns for the symmetry reasons and allowed only the formation of nano-dots.

It has been observed that in case of PET also, aromatic structure hindered the formation of ripple patterns at lower incidences while increase in incidence resulted in formation of some wavy features and has been recognized as early stage of ripple evolution.

Raman spectroscopy yields that intensity of most of the fundamental bands of the polymer has been reduced for irradiated PET samples. The decline has been observed to be more pronounced at lower oblique incidence i.e. 30°.

UV-Visible transmission studies revealed the significant decline in transmission in irradiated PET specimens. The transmission has been observed to decline further with decrease in oblique incidences. The increase in ion fluence resulted in further decline in transmission.

The specular reflectivity with respect to wavelength has been observed to increase PET samples after oblique argon ion irradiation with increase in ion fluence from $1 \times 10^{16}$ ions cm$^{-2}$ to $5 \times 10^{16}$ ions cm$^{-2}$.

The refractive index of irradiated PET samples for different fluences at varying oblique incidences have been observed to increase after oblique argon ion irradiation.
4.4 Scope of the Future Work

Further investigations in this area are:

- Tuning the amplitude and wavelength of ripple features induced by ion irradiation on polymeric surfaces for a wider range of experimental parameters.
- To explain the ion beam sputtering induced morphology using effective theoretical approaches.
- To investigate the surface features using Cross-sectional Transmission Electron Microscopy (XTEM).
- Energy Dispersive X-ray spectroscopy (EDX), Auger Electron Spectroscopy (AES) can be performed to get more information regarding concentration profile of implanted argon ions.