Chapter 7

CONCLUSION

In this thesis, the propagation characteristics of surface plasmon polaritons in passive gyrotropic and semiconductor nanowaveguides have been studied, which explores the dependence of mode dispersion on material and structural parameters, excitation frequency, and biasing magnetic field. Various plasmonic waveguide structures ranging from metal/gyrotropic slab waveguides to metal-strip/slot structures on gyrotropic dielectric and semiconductor platform have been considered to compute the dispersion behaviour of bounded plasmon modes. Numerical Method of Lines (MoLs) algorithm is used to construct the dispersion relation, starting from Maxwell’s time harmonic vectorial wave equations.

Much attention has been given to the nonreciprocal behaviour and the magneto-optic (MO) effects on the propagation of SPP modes and their effective tuning at telecommunication wavelengths, and are of vital importance in nanoscale plasmonic applications. Incorporating magneto-optic materials such as garnet films or magnetised semiconductors into the SPP based nanowaveguides, nonreciprocal phase shift could be realized in technically feasible plasmonic circuits. It has also been found that the plasmon waveguides with appropriate geometries and material parameters will provide the controlled propagation of SPPs with considerable MO phase shift, to lie within the limits of available technology.
The effect of gyrotropic substrates on fundamental SPP modes along different asymmetric waveguide structures has been studied, while ensuring sufficient energy propagation length. The main results observed are:

- The mode dispersion changes with the variations of waveguide dimensions i.e, width and thickness, keeping the fundamental behaviour as invariant.

- The degeneracy between fundamental modes is completely lifted off by moving towards thinner (nanoscale) dimensions.

- The magnetooptic effects and nonreciprocal mode propagation due to the existence of any asymmetry in material and geometrical parameters or in the magnetisation is used to demonstrate the tunability of the dispersive properties.

- A wide tunability in the dispersion relation and field distribution of terahertz magnetoplasmons, i.e. by changing internal doping concentration and external biasing magnetic field, is observed along with nonreciprocal effects in metal-strip waveguides comprising of magnetised semiconductor substrates.

- The fundamental antisymmetric (aa and sa) modes have strong confinement of the fields near the (metal-strip/gyrotropic substrate) interface and they show high sensitivity to material gyrotropy.

- Field coupling and mode confinement is greater in metal-slot waveguides than that in metal-strip waveguides. The antisymmetric (aa) mode is highly confined in the slot region, while symmetric (ss) mode is of long-ranging.

The realisation of various active plasmonic circuits or SPP-based sensor technologies, their nanoscale characterisation of geometric size, shape, and function, inclusion of various combinations of magnetooptic materials with
these structures and their possible applications are mainly suggested as an extension of this thesis work. The presented analysis can be used to create a coupling platform for SPP modes along plasmonic slot structures with a gain medium, and for all-optical field effect modulation in silicon-on-insulator based plasmonic waveguides.

It is possible to create a plasmonically activated spintronic device by combining the working principles of plasmonics and spintronics (Spinplasmonics) [127, 128, 129]. A detailed study of propagation and guiding characteristics of signals through such novel structures would be of future research interest.