Preface

Materials research in magnetic thin films, multilayers and superlattices is an interdisciplinary field. The research heavily relies on materials growth, characterization and theoretical modelling in order to understand the interface structure, interlayer coupling and transport phenomena. Knowledge of these aspects is vital for device applications. Ion irradiation and implantation have been used to modify materials properties for decades, especially in semiconductor industry. In ultrathin magnetic films and multilayers, because of their reduced dimensions, the surface and interface structure plays a crucial role to magnetic properties, e.g. magnetic anisotropies and exchange coupling. Ion irradiation can modify these magnetic properties. In this present thesis we have studied the structures and magnetic and magneto transport properties and their evolution due to ion irradiation in thin films and multilayers. We have discovered high density nonmagnetic cobalt in cobalt thin films. We have studied the effect of this high density nonmagnetic cobalt in the exchange bias behaviour of the whole cobalt film. We have also discovered that this high density nonmagnetic cobalt is superconductor with critical temperature ~9.5 K. We have then studied the ion irradiation induced modifications in a Si/Ni/Si trilayer system. For this system we have observed a novel phenomenon of oscillatory amorphization and recrystallization in Si as a function of fluence. Also the same oscillatory behaviour in coercive field and saturation magnetic moment is observed. Also we have prepared single phase $\eta$-NiSi by ion irradiation which is a technologically promising contact material and very important for CMOS technology. We have also studied the ion irradiation induced modifications in Co/Cu multilayer system. Here we have observed a negative to positive and again negative magnetoresistance transition as a function of fluence. Also ion irradiation induced grain growth in Cu is observed.

This thesis consists of nine chapters. In Chapter 1, a brief introduction to the thesis work is presented. Chapter 2 describes different thin film preparation processes and gives an overview of different aspects of interaction of energetic ion beams with solids and related phenomena. Chapter 3 is dedicated to discuss about different characterization techniques used to complete this thesis work. In Chapter 4 we have presented the discovery of high density nonmagnetic cobalt and also dependence of its growth on capping layer, thickness of the film and substrate. Cobalt is ferromagnetic at room temperature, but we have discovered a new phase of cobalt which is 1.4 times denser than usual cobalt and is nonmagnetic in nature. Many complementary techniques are used to discover this high density nonmagnetic cobalt,
but mainly X-ray reflectivity (XRR) and polarized neutron reflectometry (PNR) are used as primary techniques. Also absorption behaviour of this high density nonmagnetic cobalt is studied. Chapter 5 describes the effect of the high density nonmagnetic cobalt on the overall exchange bias behaviour of the whole cobalt thin film. Chapter 6 deals with another discovery which is the superconductivity in high density nonmagnetic cobalt. Since cobalt is ferromagnetic at room temperature it never shows superconductivity. But our high density nonmagnetic cobalt is superconductive with transition temperature ~9.5 K. The ion irradiation effects in Si/Ni/Si trilayer system are presented in Chapter 7. Here we have observed a novel phenomenon of oscillatory amorphization and recrystallization in Si as a function of fluence. The same oscillatory behaviour is observed in coercive field and saturation magnetic moment of the system. We have also succeeded to prepare single phase $\eta$-NiSi by ion irradiation in this trilayer system. $\eta$-NiSi is very important and promising contact material in CMOS technology. But we have shown that one may overcome the difficulties in formation of this material following our process. Chapter 8 describes another ion irradiation effect in Co/Cu multilayer sample. This is a standard giant magneto resistance (GMR) system. In this sample we have seen negative to positive and again to negative magnetoresistance transition due to ion irradiation as a function of fluence. A summary of the thesis together with the conclusions and future scope for some new possible studies is presented in Chapter 9.