# FERROMAGNETIC RESONANCE STUDY OF SPIN DYNAMICS IN GaMnAs FILMS

Abstract

by

Yingyuan Zhou

The ferromagnetic semiconductor GaMnAs thin films are studied experimentally using the ferromagnetic resonance (FMR) technique, with emphasis on magnetic anisotropy, spin waves and FMR line width. There are four series of $Ga_{1-x}Mn_xAs$ thin films with different Mn concentrations $x$, different layer thicknesses and different film plane indices, e.g., (110) and (311), studied in this thesis. Some of the samples were grown by low temperature molecular beam epitaxy (LT-MBE), and others were prepared by ion implantation followed by pulsed-laser melting (II-PLM).

In this thesis, FMR is used to determine all the fundamental magnetic properties of $Ga_{1-x}Mn_xAs$, including magnetic anisotropy, total magnetic moment, the Curie temperature, magneto-elastic coupling coefficients, and magnetization relaxation parameters. In some of the samples, a multi-mode spectrum, i.e., spin wave resonance (SWR) spectrum is observed. We will focus on the detailed description of such SWR and also show the relation of spin-wave

modes to the thickness and to Mn concentration $x$ in these ferromagnetic semiconductors. This method has allowed us to determine the exchange stiffness constant and the characteristics of surface spin pinning in the $Ga_{1-x}Mn_xAs$ spin system. In our study of magnetic anisotropy of $Ga_{1-x}Mn_xAs$ we find that the magnetic anisotropy fields of samples grown on high-index GaAs can be resolved into a cubic magnetic anisotropy field oriented along the crystallographic ⟨001⟩ axes and effective uniaxial magnetic anisotropy fields along higher-index directions (e.g., [110] or [311]). This is also observed in high-index samples grown by II-PLM.

The data were fitted in detail to obtain the value of magnetic anisotropy parameters and to contrast the properties of II-PLM $Ga_{1-x}Mn_xAs$ to the more widely studied behavior of $Ga_{1-x}Mn_xAs$ grown by MBE. Our results show that the magnetic anisotropy in II-PLM $Ga_{1-x}Mn_xAs$ is fundamentally similar to $Ga_{1-x}Mn_xAs$ samples grown by MBE, which indicates that two completely different growth mechanisms can lead to materials with very similar magnetic properties.