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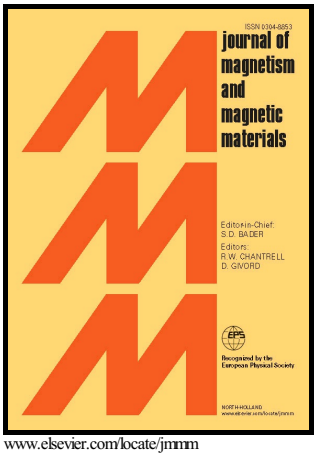

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Thin film phase diagram of iron nitrides grown by molecular beam epitaxy

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Abstract

A low-temperature thin film phase diagram of the iron nitride system is established for the case of thin films grown by molecular beam epitaxy and nitrided by a nitrogen radical source. A fine-tuning of the nitridation conditions allows for growth of α'-Fe_8N_x with increasing c/a-ratio and magnetic anistropy with increasing x until almost phase pure α'-Fe_8N_1 thin films are obtained. A further increase of nitrogen content below the phase decomposition temperature of α'-Fe_8N (180 °C) leads to a mixture of several phases that is also affected by the choice of substrate material and symmetry. At higher temperatures (350 °C), phase pure γ'-Fe_4N is the most stable phase.

Keywords: iron nitride, molecular beam epitaxy, thin films, phase diagram, nitrides, FeN

1. Introduction

The iron nitride system has attracted the interest of researchers for several decades due to the large variety of mechanical, electrical, and magnetic properties of the different occurring phases [1, 2, 3]. Magnetically, α-Fe is a soft magnetic material with large magnetization of 1714 emu/cm^3 (2.15 T) and low magnetocrystalline anisotropy of 4.8×10^5 erg/cm^3 (4.8×10^4 J/m^3) [4]. For small nitrogen concentrations, the nitrogen interstitial atoms lead to an enhanced volume of the unit cell and induce tetragonality ($c/a > 1$) into the lattice. The first effect leads to an enhanced absolute magnetization [5], the second effect leads to an increased magnetic anisotropy [6]. α-Fe with nitrogen interstitials, α-FeN_x, is not a thermodynamical phase in itself, but the additional nitrogen can be used to tune magnetic properties by distorting the lattice in c-axis direction. Only at a particular nitrogen content, an ordered phase occurs, α''-$Fe_{16}N_2$ while the unordered equivalent with the same nitrogen content is termed α'-Fe_8N. α''-$Fe_{16}N_2$ exhibits a high ferromagnetic moment with

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