International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

Magnetic Properties of Fe Films grown on Al substrates by electro-deposition

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Abstract
Fe films were deposited over an Al substrate using an electro-deposition process at various deposition periods. The X-ray diffraction technique was used to determine the structure of the films. Magnetic characteristics were measured using a vibrating sample magnetometer (VSM) in both in-plane and out-of-plane orientations. In-plane magnetic anisotropy was discovered in all films. It has been discovered that film thickness has an effect on the films' coercivity. The structural properties are connected to the magnetic properties.

Introduction
Magnetic data storage systems, magnetic micro-electromechanical system actuators, and other magnetic sensing devices have all utilized magnetic materials. Fe films have been thoroughly explored, and numerous methods for preparing Fe films have been employed. Electro-deposition is one of these techniques that is gaining popularity since it is a reasonably simple and low-cost way for fabricating magnetic thin films[1, 4]. We employed the electrodeposition approach to produce Fe films on an Al substrate in this study. Single thin films and Fe/Al multilayers have both used aluminum as a substrate. Furthermore, it is a conductor that is necessary for electrodeposition. As a function of film thickness, the structural and magnetic characteristics of these as-deposited films were examined.

Experimental Details
Electro-deposition in a solution of iron chloride (FeCl2) onto a polycrystalline Al substrate produced a series of Fe thin films. The bath was kept at a temperature of roughly 293 K (20 °C). Deposition periods ranged from 1 to 15 minutes, and sample thicknesses were determined to be between 1 and 20 m. X-ray diffraction was used to investigate the films' structural properties. Using a vibrating sample magnetometer, the magnetic moment Vs applied field curves were traced.

Results and Discussion
Using XRD, we were able to acquire XRD diffractograms of Fe samples of various thicknesses. For 1 and 20 m thick films, we found (111) and (311) Al peaks. The grain sizes were calculated using the Scherrer method and X-ray diffraction. D grain sizes range from 58 to 113 nm. We notice a monotonous increase of D (66, 70, 92, and 113 nm, respectively) with thickness h for the thicker samples (28.4, 45, 81, and 96 lm); however, no apparent variation of D with h is observed in the other thickness range.

In-plane magnetic anisotropy is detected via magnetization measurements. Electrodeposited Fe films on Si(111) and Fe on Cu substrates have both shown this property. Within the plane, we've additionally applied the magnetic field in various directions. The curves corresponding to different directions within the plane have been found to be identical. This suggests that there is no preferential orientation within the plane in these samples, implying that there is no in-plane anisotropy. Furthermore, as mentioned in the introduction, the film thickness has an impact on the coercive field values. We detect an approximately linear increase in H_C as a function of thickness for the in-plane applied field. Inhomogeneities in film thickness and varied surface roughnesses have been observed. As a result, the behaviour of the coercive fields H_C may not be related solely to thickness, but rather to surface roughness and spatial variation in film thickness.

Summary
Fe films electrodeposited onto Al substrates from a chloride bath at various deposition durations were investigated. The grain size ranges between 58 and 113 nanometers. The magnetism likes to be in the film plane, with no preferential direction within the plane, according to the hysteresis curve analysis. The coercive fields H_C show diverse behaviors depending on the thickness range; H_C appears to follow the Kittel model, which applies to spherical grains. Surface roughness and spatial variation in film thickness may also play a role in the coercive fields H_C.

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