Magnetic and Structural Properties of Poly Methyl Methacrylate (PMMA)/ Fe Film

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Abstract. Poly methyl methacrylate (PMMA) is a bio friendly polymer which forms transparent film and is used mainly in optical applications. In the present work iron (Fe) a magnetic material has been incorporated in PMMA and the magnetic and structural properties of the resulting nanocomposite has been reported. PMMA film has been prepared by solution casting method on float glass substrate. Ion Beam sputtering method was used to sputter Iron (Fe) onto PMMA to obtain Fe layer with nominal thickness of 5 nm. GIXRD pattern was recorded to study the structure of the nanocomposite film. GIXRD pattern reveals the presence of Fe nanoparticles with BCC phase. Magnetic behaviour of the film was studied by magneto optic Kerr effect (MOKE) which shows well defined hysteresis loop with a coercive field of 24.39 Oe indicating soft ferromagnetic behaviour.

INTRODUCTION

In today's generation there is growing demand of lighter, miniaturized and reliable memory storage devices. It requires flexible magnetic recording system. The main objective of using the polymer is to take their advantages of easy amenability to processing, lightweight, thin and flexible film forming ability. PMMA is a good candidate for this work. Poly methyl methacrylate (PMMA) is viewed as an important resist material for microelectronic applications because of its ability to form ultrathin cohesive film and its amenability to being etched in lithographic operations [1]. There are few reports of metal embedded in PMMA. There is report of Ag and Cu embedded into PMMA by cluster beam technique [2]. IBS is a good technique for embedding metal nanoparticles in polymer, as can be seen from reports of Co nanoparticles embedded in PVA by IBS from our group [3-5]. To the best of our knowledge, there is no report on metal nanoparticles embedded in PMMA by ion beam sputtering (IBS) technique. In the present study, PMMA is used as substrate as well as matrix. Iron (Fe) has been deposited on PMMA by ion beam sputtering (IBS) technique, Fe layer thickness is 5 nm. The PMMA/Fe film has been characterized using GIXRD and MOKE and the results are discussed in this paper.

EXPERIMENTAL DETAILS:

Prior to deposition, float glass were thoroughly cleaned. PMMA solution was prepared in chloroform and was casted on pre cleaned float glass substrate. Fe layer of 5 nm was deposited on the PMMA film by ion beam sputtering technique using Kaufman gun with the given experimental condition (Base pressure = 4.9 x 10^{-7} Torr).

The grazing incidence x-ray diffraction patterns of the samples were recorded on Bruker D8 advanced diffractometer using Cu Kα radiation the angle of incidence α was kept at 1°. The magnetization behavior was recorded using magneto optic Kerr effect (MOKE) microscope. The measurements were done ex-situ at room temperature.

RESULTS AN DISCUSSION:

GIXRD:

The GIXRD pattern of as-deposited PMMA/Fe film is presented in Figure 1. The two humps at 2θ= 14.56° and 2θ= 29.79° can be attributed to PMMA [6]. The interplanar distance d were calculated by Bragg's law which is given below

$$n\lambda = 2d \sin \theta \quad (1)$$

Where n is the order of diffraction, λ is the wavelength of the incident x-rays, d is the interplanar distance and the θ is the Bragg angle. The interplanar distance corresponding to the first and second hump is found to be 6.07 Å and 2.99 Å respectively. The low intensity hump which can be seen developing around 2θ= 43.42° can be attributed to (110) plane Fe with BCC phase. This observation is further confirmed by MOKE result. The interplanar distance for this peak as determined by Bragg's law is found to be 2.08 Å, which matches well with the value reported in the JCPDS card number 89-4186.

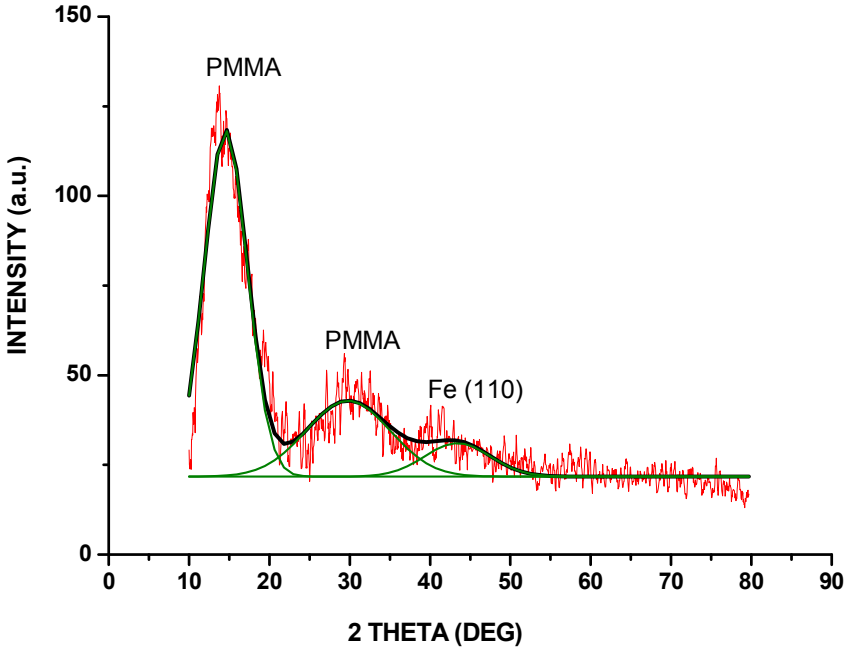

Figure 1: GIXRD pattern of as-deposited PMMA/Fe film.

MOKE:

The magnetic behavior of the as-deposited PMMA/Fe film has been investigated using MOKE microscope in longitudinal mode at room temperature. The MOKE pattern is presented in Figure 2. From this figure, one can see formation of well defined hysteresis loop indicating that the sample is ferromagnetic. This also confirms the existence of Fe in BCC phase. The coercivity is found to be 24.39 Oe. The value of saturation field is found to be 97.94 Oe. The squareness ratio is found to be 0.91. The coercivity value of 24.39 Oe the sample is an encouraging result. The coercivity reported for Fe layer of 250-350 nm on silicon reported earlier [7] showed Hc of the order of 2.5-3.5 Oe. Hence one can conclude that PMMA is a good host, in which for Fe layer as small as 5 nm also shows good soft magnetic behaviour.

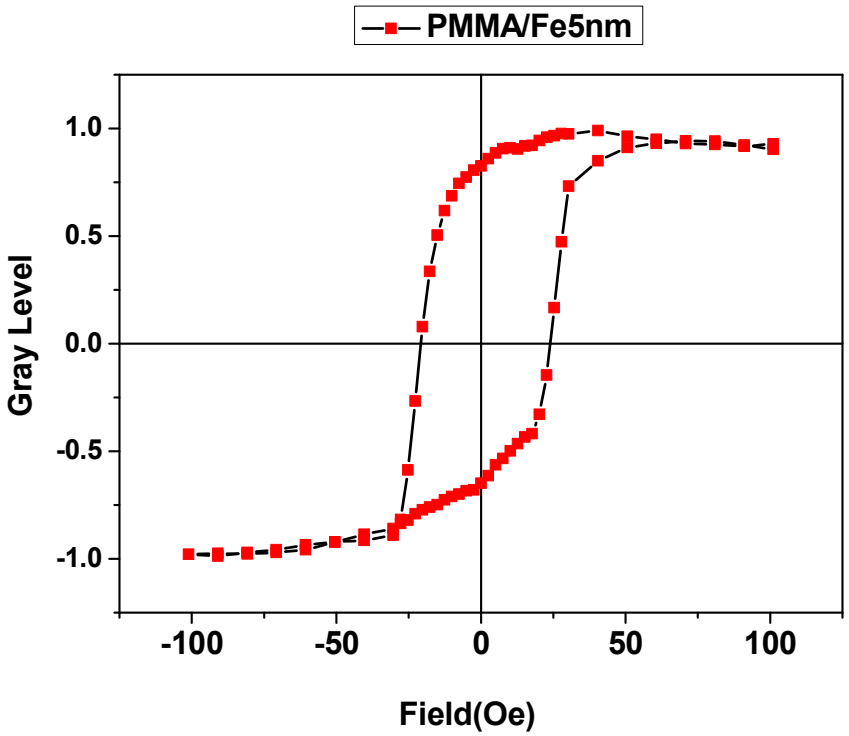

Figure 2: L-MOKE plot of PMMA/Fe films.

CONCLUSION:

In the present work, we have successfully deposited 5 nm of Fe layer onto PMMA by IBS technique. Fe layer grows with BCC phase. MOKE results show that the nanocomposite PMMA/Fe exhibits soft ferromagnetic behaviour with coercivity of 24.9 Oe.

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