PREPARATION OF MESOSCOPIC STRUCTURE POLY METHYL METHACRYLATE THIN FILMS FOR AFM DATA STORAGE DEVICES.

Chandar Shekar, B[a]*., S. Sathish[a], Sulana Sundari[b] , S.Sunnitha[b] and C. Sharmila[c]

[a] Department of Physics, Kongunadu Arts and Science College, Coimbatore, Tamil Nadu.
[b] NEAR foundation, The Nilgiris, Tamil Nadu.
[c] Department of Physics, PSGR Krishnammal College for Women, Coimbatore, Tamil Nadu.
*E-mail: chandar.bellan@ gmail.com

ABSTRACT

Poly methyl methacrylate (PMMA) thin films were prepared by dip coating method. Benzene was used as a solvent to prepare PMMA thin films for the time periods ranging from 1 min. to 1 h. The thickness of the films deposited was measured by using an electronic thickness measuring instrument (Tesatronic-TTD-20). Fourier Transform Infrared spectrum was used to identify the above said films. X-ray diffraction spectra indicated the predominantly amorphous nature of the films. Surface morphology of the coated films studied by using scanning electron microscope (SEM) indicated the absence of any pits, cracks and pin holes in the surface. Both as grown and annealed films showed smooth and amorphous structures. The closer SEM inspection revealed the presence of self assembled mesoscopic cells. The mesoscopic structure PMMA thin films could be used as an AFM-based data storage which is promising alternative to conventional magnetic data storage because it offers great potential for considerable storage density improvements.

Key words: Polymethyl methaacrylate, Dip coating, Morphology, Mesoscopic, FTIR, SEM **.**

1. INTRODUCTION

Thin films of polymer have attracted the attention of researchers mainly because of their unique properties, resistivity, electrical properties and their ease of processing and fabrication. The important advantages of polymer thin films are that they can be prepared easily and at low cost. Poly methyl methacrylate (PMMA) is one of the promising representatives of polymeric materials and there are numerous proposals for its application as dielectric in organic thin film transistors (OTFTs) (Puigdollers *et al.,*2004; Uemura *et al.,* 2003; Chandar Shekar *et al.,* 2004), sensors (Ponelyte and Palevicius, 2014) as optical lenses in cameras and optical fibers (Nakata *et al.,* 2004; Yang *et al.,* 2004) . Extensive work has been carried out on synthesis, preparation and various properties such as morphology, dielectric, optical and aging behavior of PMMA films (Sakai *et al.,* 2009; Konno *et al.,* 2009; Kim *et al.,* 2009; Mabrook *et al.,* 2009) . In the present work an attempt has been made to prepare PMMA thin films of suitable thickness by a simple dip coating method which could be used in AFM data storage devices.

2. MATERIALS AND METHODS

PMMA polymer obtained from Sigma-Aldrich was used without further purification to form the insulator layer. The cleaned glass plates were held vertically above the PMMA solution (concentration of 2.5% with benzene as a solvent) by means of mechanical arrangement capable of slow and steady vertical movement. The substrates were immersed in the solution at room temperature for different time period (1 min to 1h). After withdrawal from the solution, the substrates with the deposited film was dried in the atmosphere for 45 minutes and then kept inside an oven at 373 K for 1 h. The thickness of the coated films was measure by using an electronic thickness measuring instrument (Tesatronic-TTD-20). The PMMA films coated were identified by using FTIR spectrometer. The structure of the deposited PMMA films was studied by using XRD. The surface morphologies of the deposited PMMA films were investigated by using Scanning Electron Microscope.

3. RESULTS AND DISCUSSION

The functional groups present in the deposited polymer film were identified by FTIR spectrum. Figs 1a, b shows the FTIR spectrum of PMMA thin films of thickness 360 nm and 1810 nm respectively.

The bands observed at 677 cm $^{-1}$ and 750 cm $^{-1}$ are assigned to OH bending. The bands at 1060 cm^{-1}, 1245 cm^{-1}, 1730 cm^{-1} and 2926 cm^{-1} are respectively assigned to υ(C-O) stretching vibration, wagging vibration of C-H, C=O stretching and C-H stretching.

The X-ray diffraction pattern of PMMA thin films of thickness 360 nm and 1810 nm are presented in the Figs. 2a, b.
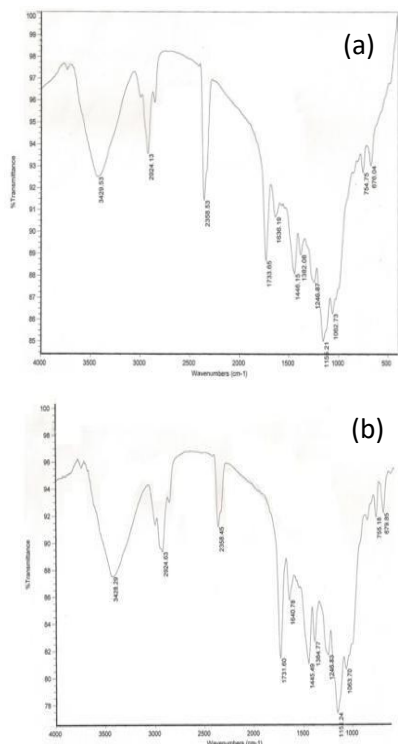

Fig. 1. FTIR spectrum of PMMA film of thickness a) 360 nm and b) 1810 nm.
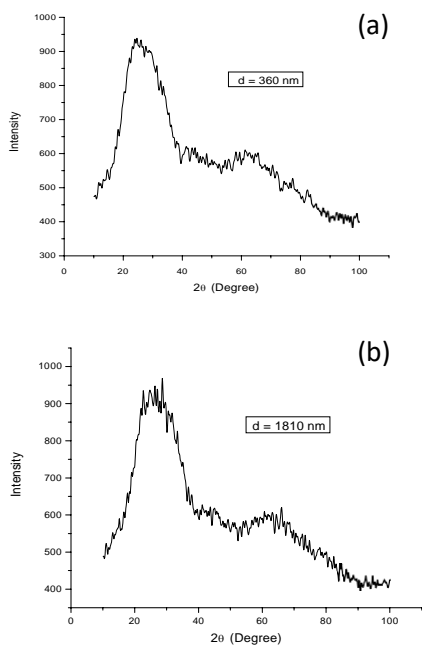
Fig 2. XRD pattern of PMMA thin film of thickness a) 360 nm and b) 1810 nm

The x-ray diffraction pattern shows large diffraction maximum that decreases at large diffraction angles indicates the amorphous nature of the film. The shape of the first main maximum indicates the ordered packing of the polymer chains. The intensity and shape of the second maxima are related to the effect inside the main chains (Chandar Shekar *et al.,* 2013) . The broad humps observed in the XRD spectrum indicate the presence of crystallites of very low dimensions. The absence of any prominent peaks in the spectrum indicates the predominantly amorphous nature of the films.

Figs. 3a, b shows the SEM image of PMMA films of thickness 360 nm and 1810 nm respectively.
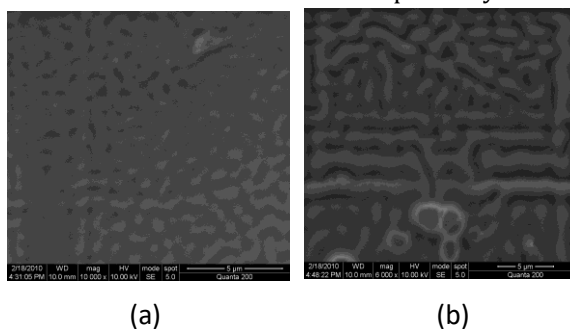
Fig. 3. SEM Micrographs of PMMA thin films of thickness a) 360 nm and b) 1810 nm.

The SEM analysis revealed self assembled mesoscopic structured films as presented in the figure, when deposited under dip coating process. The formation of the mesoscopic structures may be described with the help of the considerations presented below. Due to fast external drying, all solvents which leave the solution are immediately removed from the film. Then at an early stage of the evaporation process, a polymer rich layer is formed. The thickness of such layers may be of the order of mesoscopic scale range. The dip coating process presented in this work is simple, highly reproducible and permits fabrication of large areas of mesoscopic structured films, which have a potential as membranes, long period gratings and photonic molecules. The surface morphology is quite homogenous and amorphous in nature without any pits, cracks and pinholes. The mesoscopic structures obtained for the very thin film of PMMA could be used as an AFM-based data storage which is promising alternative to conventional magnetic data storage because it offers great potential for considerable storage density improvements.

4. CONCLUSION

The FTIR analysis indicated the absence of any impurity in the PMMA thin films. The X-ray diffraction pattern revealed the amorphous nature of

the films studied. The SEM analysis revealed the phenomenon of self assembly on the mesoscopic scale. The dip coating process presented in this work is simple, highly reproducible and permits fabrication of large areas of mesoscopic structured films. The mesoscopic structured films have the potential as membranes, long period gratings, photonic molecules and AFM based data storage system.

REFERENCES

Chandar Shekar, B., M. Na, J. Lee and S.W. Rhee, (2004). *Mol. Cryst. Liq. Cryst.* **424**: 43-53.

Chandar Shekar, B., S. Sathisha and R. Sengoden, (2013). *Physics Procedia.* **49**: 145 – 157.

Kim, T.G., E.H. Jeong, S.C. Lim, S.H. Kim, G.H. Kim, S.H. Kim, H.Y. Jeon and J.H. Youk, (2009). *Synthetic Metals* **159**: 749-753.

Konno, K., H. Sakai, T. Matsushima and H. Murata, (2009). *Thin Solid Films* **518**: 534-536.

Mabrook, M.F., A.S. Jombert, S.E. Machin, C. Pearson, D. Kolb, K.S. Coleman, D.A. Zeze and M.C. Petty, (2009). *Materials Science and Engineering: B* **159-160**: 14-17.

Nakata, K., M. Ohji, Y. Ikuno, S. Kusaka, F. Gomi, M. Kamei, D.F. Ross and Y. Tano, *Am. J. Ophthalmol.* **137**: 760-762.

Ponelyte, S. and A. Palevicius, (2014). *Sensors* **14**: 6910-6921.

Puigdollers, J., C.V.I. Martin, A. Orpella, M. Vetter and R. Alcubilla, (2004). *J. Non-Crystalline Solids* **338-340**: 617-621.

Sakai, H., K. Konno and H. Murata, (2009). *Thin Solid Films* **518**: 510-513.

Uemura, S., M. Yoshida, S. Hoshino, T. Kodzasa and T. Kamata, (2003). *Thin Solid Films* **438-439**: 378 – 381.

Yang, D.X., J. Yu, X. Tao and H. Tam, (2009). *Materials Science and Engineering A* **364**: 256-259.