Electrochemical Preparation of Tm-Co Magnetic Films in Dimethylsulfoxide

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Dimethylsulfoxide (DMSO) is a fine non-proton polar solvent. $Tm(NO_3)_3$ also has highly soluble in DMSO(236g L^{-1}). $Tm(NO_3)_3$ have strong electrolyte property in DMSO(Fig 1). Its limiting molar conductivity Λ_m^{∞} is 146.8S cm^2 mol^{-1}. Cyclic voltammetry has been used to investigate the electrochemical behaviour of the Tm^{3+} ion in 0.01mol L^{-1} $Tm(NO_3)_3$-0.1mol L^{-1} $LiClO_4$-DMSO system on Pt electrode at 299K. The experimental results of cyclic voltammetry indicate that the reduction of Tm^{3+} ion is an irreversible process [1]. The transfer coefficient and the diffusion coefficient of Tm^{3+} ion are 0.05 and 5.74×10^{-6} cm^2 s^{-1}, respectively.

Tm-Co alloy films have been prepared by the potentiostatic deposition technique. The deposition bath contains 0.05 mol L^{-1} $Tm(NO_3)_3$ - 0.25mol L^{-1} $CoCl_2$ - 0.1mol L^{-1} $LiClO_4$- DMSO. Citric acid (0.1mol L^{-1}) has been used as a complexing agent and polyethylene glycol-1000 (0.05mol L^{-1}) has been added to system as a stabiliser. A pure copper foil has been used as the cathode substrate. Tm-Co alloy films have been prepared by the potentiostatic technique in the range –1.800～-2.500V. The uniform, adhesive and showed a metallic luster Tm-Co alloy films have been obtained in the range –2.000～-2.400V. The morphology of Tm-Co alloy films has been observed by SEM. Fig 2 is a ×5000 photograph of alloy film (The deposition potential is –2.000V. Deposition time is 45min). The thickness of the alloy film is about 120μm. Spheric alloy grains about 0.5～1μm are compact. Tm content in this film is 31.96wt.%. The phase of the alloy films has been analyzed by XRD (Fig 3). There are two diffraction peaks at 43deg. and 50deg.. The diffraction peaks belong to substrate Cu (111), (200). A broad peak displays in figure (near 2θ = 45deg.). This is character of the amorphous Co alloys. It proves that the alloy films are amorphous [2].

The magnetic properties of Tm-Co alloy films have been ascertained by MPMS-7. Asymmetrical hysteresis curve is shown in Fig 4.The saturated magnetization intensity M_s, coercive force (Hc) and remanence (Br) are 58750A m^{-1}, 809Oe and11554 A m^{-1} at 5K, respectively. Tm-Co alloys possess large saturated magnetization intensity and high coercive force at 5K. The saturated magnetization intensity M_s, coercive force (Hc) and remanence (Br) are 54791A m^{-1}, 48Oe and 183 A m^{-1} at 293K, respectively. These data indicate that the amorphous Tm-Co alloy films have soft magnetic properties at 293K. Thus, this kind of rare earth films prepared from organic solvent could has potential application as magnetic materials.

[1] A. J. Bard, L.R. Faulkner. *Electrochemical Methods*. pp. 236, 231, John Wiley & Sons, Inc, New York(2001).
[2] X.H. Zheng, X.C. Ma, T.P. Xuan, et al. *J. Zhejiang University of Technology*. **28(2)**, 104 (2000).

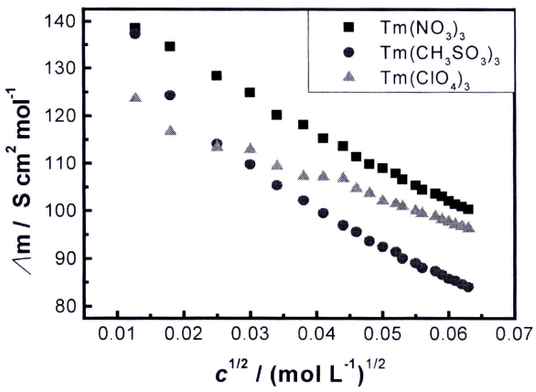

Fig 1 The plot of $\Lambda_m \sim \sqrt{c}$ of three thulium salts in DMSO at 298K

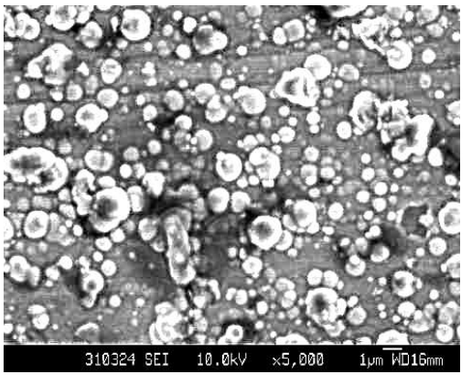

Fig 2 SEM photogrph of Tm-Co alloy film

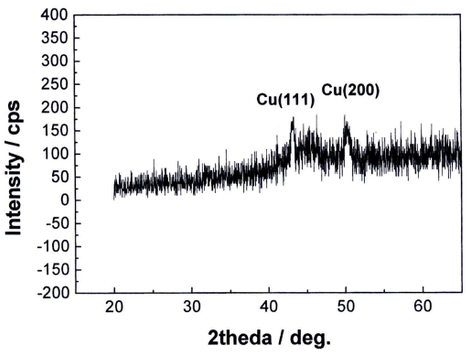

Fig 3 XRD pattern of Tm-Co alloy film

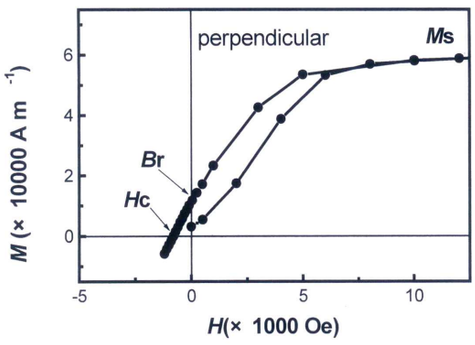

Fig 4 Hysteresis loop of Tm-Co alloy film at 5K