Iron Thin Films Electrodeposited in A Strong Magnetic Field

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The control of crystallographic orientations of transition metal films has both scientific and technological importance. Examples of the technological applications can be seen in the perpendicular magnetic recording media and the water electrolysis electrode. In conventional manufacturing processes, the control is mainly conducted by recrystallization methods. In terms of production costs, however, a new method is required for certain transition metals such as iron.

Several research groups have reported that unique characteristics associating with crystallographic orientations appear, when a magnetic field is superimposed to an electrodeposition process [1-3]. This study presents magnetic field effects on crystal orientation and morphology of the electrodeposited iron films.

The cathode was a sheet of copper (10 x 10 x 0.2 mm, Cu 99.99 %). The anode was a sheet of pure iron (10 x 10 x 0.2 mm, Fe 99.99 %). The reference was an Ag / AgCl electrode. An electrolyte composition was 0.90 mol l^{-1} $FeSO_4 \bullet 7 H_2O$, 0.15 mol l^{-1} $FeCl_2 \bullet 4 H_2O$ and 0.43 mol l^{-1} NH_4Cl. The pH of the electrolyte was adjusted to 1.5 with H_2SO_4. The electrolyte temperature was maintained at 298 K.

Iron was galvanostatically electrodeposited at several current densities (3, 5, 10 and 30 mA cm^{-2}), until the amount of electrical charge reached 150 C cm^{-2}.

Figure 1 shows the pole figures of iron (110) plane electrodeposited at 10 mA cm^{-2}, in (a) no magnetic field and (b) a magnetic field of 5 T. In no magnetic field (a), there is a circle pattern at the angle of 30 degrees to the direction normal to a substrate plane, which means that (211) plane is preferred orientation parallel to the substrate. This circle pattern means that (110) planes face all directions. On the other hand, in a magnetic field (b), there is a crystal orientation in same direction to the magnetic field vector.

Figure 2 shows the pole figures of iron (110) plane electrodeposited at 30 mA cm^{-2}. In no magnetic field (a), there is a similar circle pattern at the angle of 35 degrees, which means that (111) plane is parallel to the substrate. On the other hand, in a magnetic field (b), there is also a crystal orientation. However, it should be noted that the crystal orientation does not appear clearly.

It is found that iron (110) plane was oriented by a magnetic field. The evolution mechanism of oriented (110) plane will also be discussed through the observation of the initial stage of electrodeposition by AFM in the presentation.

References
[1] O. Devos, A. Olivier, J. P. Chopart, O. Aaboubi and G. Maurin, *J. Electrochem. Soc.*, **145**, 401 (1998)
[2] S. Bodea, L. Vignon, R. Ballou and P. Molho, *Phys. Rev. Lett.*, **83**, 2612 (1999)
[3] K. H. Lee, J. Yoo, J. Ko, H. Kim, H. Chung, D. Chang and J. Y. Lee, *Physica C*, **372**, 866 (2002)

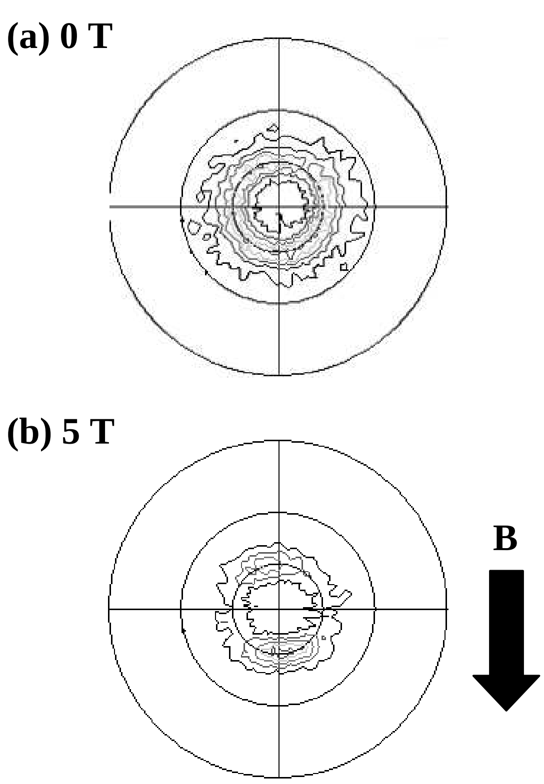

Fig. 1 Pole figures of iron (110) plane at 10 mA cm^{-2}, in (a) no magnetic field and (b) a magnetic field of 5 T.

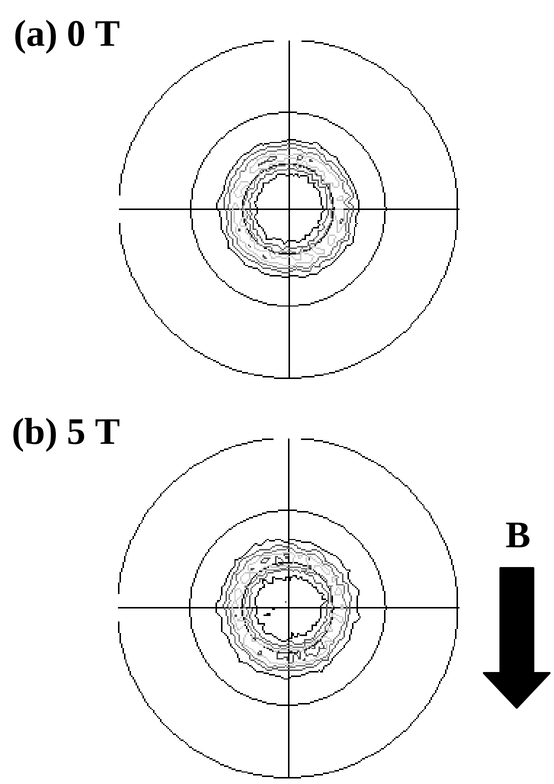

Fig. 2 Pole figures of iron (110) plane at 30 mA cm^{-2}, in (a) no magnetic field and (b) a magnetic field of 5 T.