Effect of microstructure on the Friction Properties of the Electroless Ni-P Deposits

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Electroless Ni-P is widely used in the chemical, mechanical and electronic industries because of its excellent hardness, corrosion and wear resistance, solderability and its inherently uniform deposit thickness. Most of the earlier studies on Ni–P deposits have focused on plating using electroless systems. In recent years, many works have been reported that are mainly focused on process, microstructure and property of the electroless plating, even the effect of heat treatment on them. In this study, we studied the effect of heat treatment on fractional coefficient of the Ni-P deposits which there are different phosphorus contents and microstructure. The strength mechanism of heat treatment had been investigated.

Low carbon steels with a size of 15x15x2mm were used as substrates for electroless plating Ni-P alloys. The composition of the electroless solutions were nickel sulfate(20g/l for sample 1, 26g/l for sample 2, 40g/l for sample 3), sodium hypo-phosphite(30g/l) and complex agents. The samples were plated in the electroless bathing for 2 hours at 85°C. Deposited samples were analyzed by X-ray diffraction and microhardness tester. Heat treatment of these Ni-P samples was carried out in a furnace in a protective atmosphere of flowing high purity nitrogen gas at various temperatures (100, 400°C) for 1 hour. The wear tests at room temperature were performed on a MS-T3000 friction-wear instrument in air under dry sliding conditions. All tests were performed under a load of 20 N.

Figure 1 shows the X-ray diffraction patterns as-plated sample 1, 2 and 3, respectively. It could be seen that the patterns of sample 1 is the wide amorphous diffraction peak. However, sample 3 reveals the narrower and sharper crystalline peak, which is corresponded to the peak of crystalline nickel (111). Sample 2 had the common characteristics of sample 1 and sample 3. Namely, sample 2 is a mixture of nano-size nickel and amorphous phase. These results indicate that the deposit with different crystalline state could be obtained through adjusting the process of electroless. The EPMA analysis resulted that the content of phosphorus for sample 1, 2 and 3 was 12.7wt.%, 10.6wt.% and 6.9wt.%, respectively.

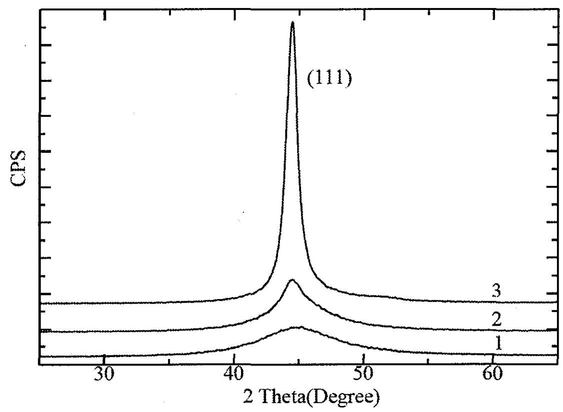

Fig. 1. XRD patterns of sample 1, 2 and 3 deposits before heat treatment.

Figure 2 and 3 show the X-ray diffraction patterns after being heat treated at 200°C and 400°C for 1 hour of sample 1, 2 and 3, respectively. In Fig. 2, XRD analysis shows that t no obvious precipitated phase was observed in these samples of heat treated at 200°C for 1 hour, but the weak changing of diffraction pattern could be noticed.

For example, the full width at half maximum (FWHM) became wide for sample 3 and there are fine precipitate for sample 1 and 2. For the samples of heat treated at 400 °C, clear crystalline phase of fcc Ni and intermetallic compound Ni_3P were found from the diffraction patterns.

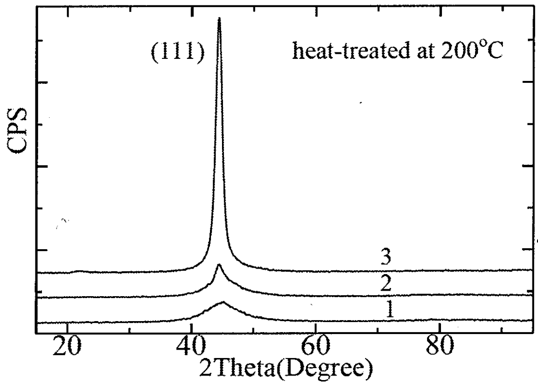

Fig. 2. XRD patterns of sample 1, 2 and 3 deposits

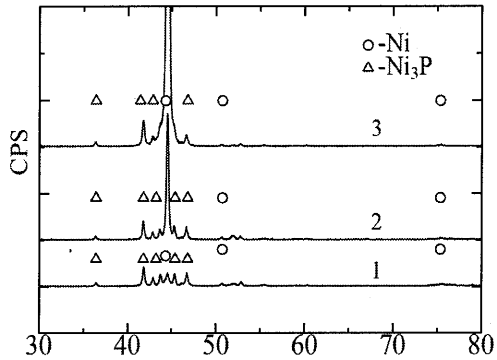

Fig. 3. XRD patterns of sample 1, 2 and 3 deposits

Figure 4 shows the variation of microhardness for these as-plated samples and being after heat treatment at 200°C and 400°C for 1 hour, respectively. It shows that the as-plated hardness of sample 3 whose whole matrix is almost nanocrystalline phase, nearly reached to 800Hv. This value is close to the results of amorphous after be heat treated at 400°C 1 hour of Ni-P deposits. The changing trend of hardness with heat treat temperature for sample 3 is different with that of sample 1 and 2, it has a slight decrease for sample 3 after being heated at 200°C for 1 hour. But the hardness of sample 1 and 2 are increased with the increasing of heat treat temperature. This implied the strengthening mechanism for Ni-P deposit is depended on phosphorus content.

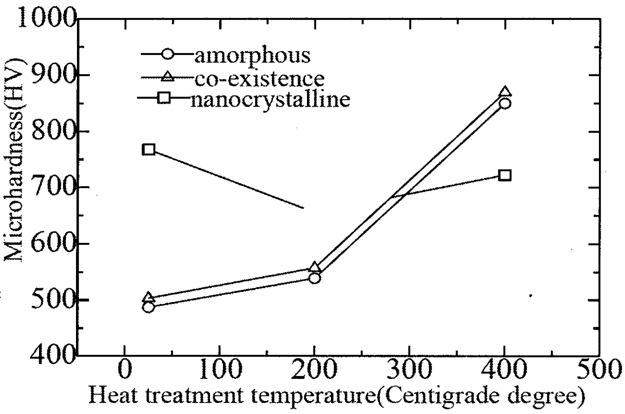

Fig. 4. Hardness variation of sample 1, 2 and 3 deposits (at as-plated, 200°C,400°C for 1 hour, respectively).

The friction coefficient of the as-plated and heat treated deposits is found that the sample 3 (nanocrystalline phase) exhibit low friction coefficient, in spite of its as-plated or after being heat treatment. Additionally, it can also be noticed that the fluctuation of friction coefficients for sample 1 and 2 after being heat treated at different temperature. This implied the variation of abrasion mechanism during heat treated Ni-P deposits. The wear mechanism was from adhesive wear to abrasive wear with the precipitating of Ni_3P particle. Combined with the analysis results about the structure analysis of X-ray in 3.2, it could be seen that the amount of the nanocrystalline obviously affected the wear rate of Ni-P deposits.