The mechanical properties and the thermal stability of nickel – dispersed oxide particle by using electrodeposition method

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1. Introduction

Nickel - oxide dispersion composites have been investigated very largely at the in variety of the research fields. It is well known that nano size oxide particles of in a metal can lead to an improvement of the mechanical properties such as the tensile strength, microhardness, wear resistance [1-3]. The grain size of electrodeposited nickel can be reduced to the nano-regime using additives such as coumarin and saccharin. However, these additives introduce carbonaceous material or sulfur into nickel. Sulfur acts as solid solution strengthener and also causes intergranular embrittlement. In order to avoid the incorporation of sulfur and carbon in nickel, concentrated nickel sulfamate electrolyte are recommended for electroforming of low stress deposits [4]. So, this work used sulfamate bath to avoid this weak point. Next to use in the high temperature region, it has to be conducted to investigate the influence of amount of oxide and annealing temperature.

This present work investigates the thermal stability effects of adding the different three Titania nanoparticle oxide concentrations and of observation according to the increment with amount of the Titania nanoparticle. And it was measured the tensile strength of different amount of particle in a sulfamate bath.

2. Experimental

Deposition occurs in a sulfamate bath containing 1.39mol/ℓ $Ni(SO_3NH_2)_2 \cdot 4H_2O$, 0.65 mol/ℓ H_3BO_3. The experiment was performed at 60℃ and 100mA/cm^2, on a 3×10 cm^2 SUS316 cathode. The substrate was polished, degreased, activated before each deposition. The Pt anode is the same size as the cathode. TiO_2 particle powder, which diameter is about 25-70nm (produced by the Aldrich Co.), was introduced into the bath. The concentration of the Titania particles in a bath was 0.02 mol/ℓ, 0.05 mol/ℓ, 0.1 mol/ℓ. The annealing was performed at temperatures ranging from 200℃ to 950℃ and was raised to 100℃. After the annealing, the specimens were quenched by cooling water. The measurement of the microhardness tests were carried out an Akashi HM-124 hardness test machine with a 50g load, 10 second per each specimen and ten times measurement. Tensile strength test was performed on a microtensile strength tester (produced by the R&B co.) by 1mm/min speed. And the cross-sectional rupture areas of the tensile strength specimen were observed by Scanning Electron Microscope (JEOL SEM5200).

3. Results and discussion

Fig. 1 shows the microhardness values obtained from the electrodeposited nickel – dispersed Titania particle after the annealing 2hrs at each temperature. The microhardness values tend to decrease according to increase annealing temperature. And there is a some relation between the microhardness decreasing rate and the concentration of the titania particle. The hardness of accompanying annealed temperature decreased with higher temperature. And the more add the oxide, the more decreasing rate shows a slight decline. In the range of 200℃ to 950℃, the hardness of Ni/oxide deposit depended on concentration. Fig. 2 presents the tensile strength curves of the nickel-dispersed oxide particle at different oxide concentration. 0.02 mol/ℓ and 0.05 mol/ℓ concentrations are a little difference, but 0.1 mol/ℓ concentration is differ from other two concentrations. It shows that the more add the Titania particle, the more increasing ultimate tensile strength, but the elongation may be seen non-related with amount of oxide. Fig.3 shows the Cross-sectional rupture image of the electrodeposited nickel – dispersed oxide particle. More adding oxide particles, then it were observed less pore crack regions.

4. Conclusion

The thermal stability of the electrodeposited nickel – dispersed nanosized particle was investigated in a range of 200℃ to 950℃. And the tensile strength was measured and cross-sectional rupture region was observed according to the different concentration of the oxide particle concentration. The results show: first, the hardness of accompanying annealed temperature decreased with higher temperature. And the more adding the oxide, the more decreasing rate shows a slight decline. Second, the more adding the Titania particle, the more increasing ultimate tensile strength, and the elongation may be seen decreased with amount of oxide particles.

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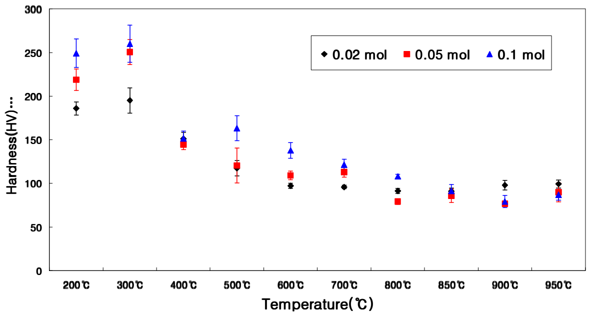

Fig. 1. Average results of the microhardness measurement according to the increment of the temperature.

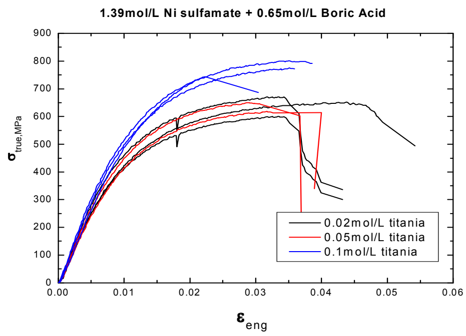

Fig. 2. Tensile strength test curves in the different concentration of the oxide particle.

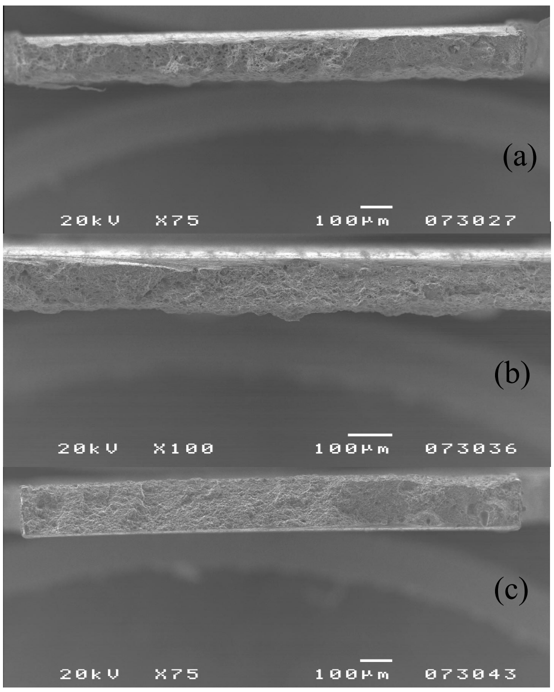

Fig. 3. Cross-sectional area image of the electrodeposited nickel – dispersed oxide particle tensile strength test specimens.
(a) 0.02 mol/ℓ (b) 0.05 mol/ℓ (c) 0.1 mol/ℓ