Relationship between Current Density, Crystal Grain Size, Composition and Hardness in Electrodeposited Ni-Co Alloys

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Nickel, cobalt, and their alloys are important engineering materials in many applications because of their unique properties, such as magnetic, heat-conductive and high hardness. Their alloy films have attracted much attention and are widely used in micro-electrical-mechanical systems (MEMS) devices due to excellent electrical and mechanical properties. Pure Ni films are known for high hardness property, and the mechanical strength can be further improved by solid solution strengthening. Electroplating (EP) is often used in preparation of Ni-Co alloy films because the morphology, crystal structure, and deposition rate of the deposited materials can be facilely controlled by varying the EP parameters [1], such as the current density, bath composition, and temperature [2]. Reliability of electronic components is highly dependent on the mechanical property, which is closely related to its average grain size according to the Hall-Petch relationship [3]. Therefore, in this study, the effects of applied current density on average grain size, Vickers hardness, and micro-mechanical properties of electrodeposited Ni-Co films are evaluated for fabrication of micro-components in electronic devices.

The electrolyte used in this work was chloride-based which consists of 0.1 M $NiCl_2 \cdot 6H_2O$ and 0.1 M $CoCl_2 \cdot 6H_2O$, and 0.002 M HCl was used to adjust the pH value. The current density was varied from 1 to 10 mA/cm^2.Crystalline structure of the Ni-Co films was characterized by X-ray diffraction (XRD), and the average grain size was calculated using the XRD results and the Scherrer equation. The mechanical properties were evaluated using Vickers hardness measurement.

The Ni-Co films showed bright silver-colored surfaces. An increase of in the hardness was observed as the current density increased. On the other hand, more defects were observed on surface of the film when a higher current density was used as shown in the image. This was a result of the promoted side reaction, hydrogen evolution in this case.

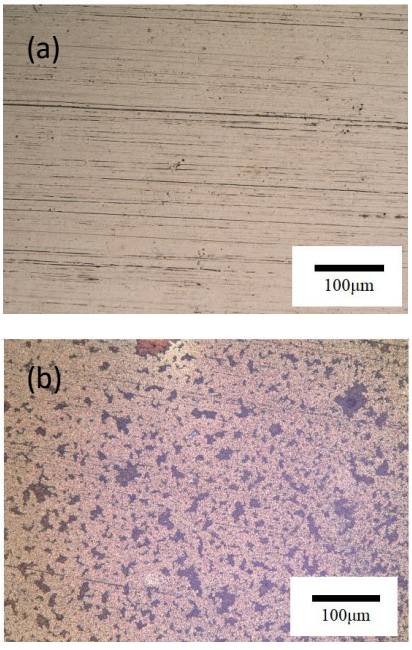

Fig. 1. The optical microscope photographs of Ni-Co alloy electrodeposited with current of (a) 2mA and (b) 10mA.

References

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