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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Miniaturized electronic devices have becoming more complex and smaller to fulfill requirements in future trends of electronics industry, such as sizes of the movable component in microelectromechanical systems (MEMS) are often on the micro-scale or nano-scale, and the high-density packaging of semiconductor devices is increasingly demanded. Much interest is focused on Ni alloys due to their corrosion resistance, excellent magnetic and mechanical properties. Electrodeposition is widely applied in fabrication of electronic components because of the ease in controlling the morphology, crystal structure, composition and deposition rate of the electrodeposited materials. Electrodeposition also offers a higher deposition rate, better crystallinity and higher stability of the electrolyte.

This thesis aims to develop a new methodology toward the application of alloy micro-components manufacturing by combining electrodeposition method and micromechanical characterization. Ni-Co and Ni-B alloy films are fabricated by electrodeposition method. Their morphology, average grain size and composition are manipulated by varying the electrodeposition parameters including current density, bath composition and additives. The reaction mechanism of alloy electrodeposition is studied through electrochemical analytical methods, such as cyclic voltammetry and linear sweep voltammetry. The micro-mechanical strength and deformation behaviors of Ni-Co and Ni-B alloys are characterized through micro-compression tests using non-tapered pillar type micro-specimens. Their specimen size effects are also investigated toward the design of micro-scale components in miniaturized devices.

Ni-Co alloy films were fabricated by electrodeposition method. The morphology, crystal structure and composition were controlled by varying the electrodeposition parameters such as current density, pH and additives. In this study, the effect of additive bromide ions on Ni-Co electrodeposition was studied by electrochemical analysis, and bromide ions were found to act as accelerators in the reduction of Co and suppressors in the reduction of Ni. The anomalous codeposition behavior was found to be promoted in a lower pH environment. The introduction of

bromide ions and the low pH environment resulted a synergistic effect to the anomalous codeposition behavior.

The micro-mechanical properties of electrodeposited Ni-Co alloys were studied by conducting micro-compression tests using micro-pillar specimens to investigate the mechanical strength at the microscale. Yield strength was found to be highly dependent on average grain size which indicated grain boundary strengthening effect. The highest yield strength at 2.37 GPa was obtained from a micro-pillar fabricated from an alloy electrodeposited with the sulfamate bath containing nickel bromide and the surface brightener, with an average grain size of 13.6 nm and composed of 58.48 at.% of cobalt.

Ni-B alloy films with the B content ranged from 2.8 at.% to 14.3 at.% were electrodeposited by controlling the current density. The B content was found to decrease along with an increase in the current density. Surface roughness (R_a) of the alloy films decreased following with an increase in the current density. Micro-compression test was conducted to appraise the micro-mechanical strength. As-deposited Ni-B alloy films showed high yield strengths in a range of 4 GPa to 5 GPa. The high strength was further enhanced after the 250 °C heat treatment for 1 h to 4 h, and a maximum fracture strength of 5.52 GPa was obtained owing to the precipitation of intermetallic compound, Ni_3B. The electrodeposited Ni-B alloy films showed an excellent micro-mechanical strength and thermal stability and demonstrated the applicability toward miniaturized electronics.

Ni-B alloys with boron content of 0.52 wt.% were fabricated into pillar type micro-specimens for micro-compression test to investigate the specimen size effect on their mechanical strength. As-deposited nickel-boron alloy exhibited a high yield strength and ductile compressive deformation mode. As the sample size decreased, a smaller-is-stronger sample size effect was observed. Through the Weibull statistics, we find that the micro-specimens showed flaw-sensitivity, and the dependence of their strength on the specimen size can be explained by the lower probability of having weak flaws in smaller specimens.

In this thesis, Ni-Co and Ni-B alloy films were produced by electrodeposition method and micro-pillar type specimens were fabricated by focused ion beam milling, which provide a novel methodology for fabricating metallic micro-components. The micro-mechanical strength and deformation behaviors of Ni-Co and Ni-B alloys are characterized with consideration of sample size effect. The study will have contribution toward the design of micro-scale components in miniaturized devices.