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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 ）

In this thesis, effects of the SC-CO_2 emulsified electrolyte in co-electrodeposition of metal matrix composite are investigated. Explanations on effects of the SC-CO_2 emulsified electrolyte, the SC-CO_2 soft particles and the TiO_2 hard particles are provided, theoretical models are provided. A quantitative evaluation method to determine the uniformity of TiO_2 in the Ni-TiO_2 composite films is developed. The micro-mechanical property and corrosion resistance are evaluated to demonstrate the advantage in practical applications.

In chapter 2, with addition of SC-CO_2 and surfactants into the electrolyte, SC-CO_2 micelles were formed and worked as soft particles in the electrolyte to improve the transfer efficiency of materials from the bulk to the electrode surface. The continuous motion of SC-CO_2 micelles generated particle films which could accelerate the transfer efficiency of the solid TiO_2 nanoparticles. In addition, the attractive interaction between SC-CO_2-SDS micelles and TiO_2 nanoparticles reduced the agglomeration of TiO_2 nanoparticles and further raised the efficiency of transfer TiO_2 nanoparticles by the particle film from bulk to the electrode surface. As results of improved TiO_2 mass transfer, Ni-TiO_2 composite films fabricated by the SC-CO_2 assisted co-electrodeposition had a higher TiO_2 content, better dispersity and higher hardness when compared with the composite films prepared by the conventional method.

In chapter 3, SC-CO_2 soft particles suspending in the Ni-TiO_2 electrolyte were formed by emulsifying the electrolyte with Sc-CO_2 and surfactants. The CO_2 volume fraction in the emulsified electrolyte and the applied pressure were varied to manipulate physical properties of the SC-CO_2 soft particles in the emulsified electrolyte. TiO_2 content slightly decreased following an increase in the CO_2 volume fraction. The dispersity of TiO_2 particles dispersion did not changed much as the CO_2 volume fraction varied. A local minimum in the Ni grain size, a local maximum in the TiO_2 content and a local maximum uniformity of the dispersity were observed when the applied pressure increased. The high TiO_2 content, and uniform dispersion of the TiO_2 nanoparticles were all results of the improved transfer efficiency by the SC-CO_2 soft particles in the emulsified electrolyte.

In chapter 4, the effect of suspended TiO_2 particle sizes on the SC-CO_2 assisted co-electrodeposition was examined by co-electrodeposited Ni-TiO_2 composite films with three different TiO_2 particle sizes. An enhancement on the Ni grain refinement effect was found with the increasing of average size of TiO_2 particles used in the SC-CO_2 assisted co-electrodeposition. Incorporating amounts of TiO_2 particles also increased with the average size of TiO_2 particles. In contrast, the uniformity of incorporated large TiO_2 particles in the Ni matrix was poor while the incorporated small TiO_2 nanoparticles dispersed more uniform in the Ni matrix. This result investigated that the effect of SC-CO_2 soft particles on improving the dispersity of incorporated TiO_2 solid particles in the Ni matrix reduced with the increase of solid particle size. As a result of Ni grain refinement, incorporating of TiO_2 particles, and the improved uniformity of incorporated TiO_2 particles in the Ni matrix, highest hardness at 1274 HV was obtained in the Ni-TiO_2 composite with the most uniform TiO_2 particle distribution using smallest TiO_2 nanoparticle.

In chapter 5, micro-mechanical properties and the sample size effect in Ni-TiO_2 composites prepared by co-electrodeposition with supercritical CO_2 emulsified electrolyte were evaluated by micro-compression tests. The average grain sizes of the Ni matrix in the conventional Ni-TiO_2 composite films and SC-CO_2 Ni-TiO_2 composite films were 23.6 nm and 9.7 nm, respectively. The TiO_2 content was 3.83 wt% for the conventional Ni-TiO_2 composite films and 4.05 wt% for the SC-CO_2 Ni-TiO_2 composite films. The strengths of the SC-CO_2 Ni-TiO_2 pillars were all much larger than those of the conventional Ni-TiO_2 pillars. The yield strength of a SC-CO_2 Ni-TiO_2 having the dimensions of 7.5 μm × 7.5 μm × 15 μm was 3.4 GPa. The value was about 3 folds of the yield strength of a conventional Ni-TiO_2 pillars having the same sizes. Regarding the sample size effect, the strength was independent of the sample size for the SC-CO_2 Ni-TiO_2 pillars when one side of the cross-section varied from 5 μm to 10 μm, and the sub 10 nm average Ni grain size was suggested to be the main cause.

In chapter 6, as a pre-study for applying SC-CO_2 assisted co-electrodeposition in fabrication of Au matrix composite materials, Conventional co-electrodeposition of Au-TiO_2, a potentially alternative material of Si for the proof mass in micro-accelerometer, was conducted. Effects of the TiO_2 content in Au matrix on surface morphology, crystalline structure, microstructure, and the mechanical properties of the composite film were investigated. Surface roughening and grain refinement of Au was observed by SEM) and XRD as results of the incorporation of TiO_2 nanoparticles into Au matrix. In addition, the Vickers hardness and compressive yield strength was clearly improved with only 2% reduction in the mass density comparing to pure Au.