

論文 / 著書情報
Article / Book Information

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種別(和文)	論文要旨
Type(English)	Summary

論文要旨

THESIS SUMMARY

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Department of Graduate major in ライフエンジニアリング コース
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申請学位(専攻分野)：博士 (工学)
Academic Degree Requested Doctor of
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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-CO₂ emulsified electrolyte in co-electrodeposition of metal matrix composite are investigated. Explanations on effects of the SC-CO₂ emulsified electrolyte, the SC-CO₂ soft particles and the TiO₂ hard particles are provided, theoretical models are provided. A quantitative evaluation method to determine the uniformity of TiO₂ in the Ni-TiO₂ 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-CO₂ and surfactants into the electrolyte, SC-CO₂ 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-CO₂ micelles generated particle films which could accelerate the transfer efficiency of the solid TiO₂ nanoparticles. In addition, the attractive interaction between SC-CO₂-SDS micelles and TiO₂ nanoparticles reduced the agglomeration of TiO₂ nanoparticles and further raised the efficiency of transfer TiO₂ nanoparticles by the particle film from bulk to the electrode surface. As results of improved TiO₂ mass transfer, Ni-TiO₂ composite films fabricated by the SC-CO₂ assisted co-electrodeposition had a higher TiO₂ content, better dispersity and higher hardness when compared with the composite films prepared by the conventional method.

In chapter 3, SC-CO₂ soft particles suspending in the Ni-TiO₂ electrolyte were formed by emulsifying the electrolyte with Sc-CO₂ and surfactants. The CO₂ volume fraction in the emulsified electrolyte and the applied pressure were varied to manipulate physical properties of the SC-CO₂ soft particles in the emulsified electrolyte. TiO₂ content slightly decreased following an increase in the CO₂ volume fraction. The dispersity of TiO₂ particles dispersion did not changed much as the CO₂ volume fraction varied. A local minimum in the Ni grain size, a local maximum in the TiO₂ content and a local maximum uniformity of the dispersity were observed when the applied pressure increased. The high TiO₂ content, and uniform dispersion of the TiO₂ nanoparticles were all results of the improved transfer efficiency by the SC-CO₂ soft particles in the emulsified electrolyte.

In chapter 4, the effect of suspended TiO₂ particle sizes on the SC-CO₂ assisted co-electrodeposition was examined by co-electrodeposited Ni-TiO₂ composite films with three different TiO₂ particle sizes. An enhancement on the Ni grain refinement effect was found with the increasing of average size of TiO₂ particles used in the SC-CO₂ assisted co-electrodeposition. Incorporating amounts of TiO₂ particles also increased with the average size of TiO₂ particles. In contrast, the uniformity of incorporated large TiO₂ particles in the Ni matrix was poor while the incorporated small TiO₂ nanoparticles dispersed more uniform in the Ni matrix. This result investigated that the effect of SC-CO₂ soft particles on improving the dispersity of incorporated TiO₂ solid particles in the Ni matrix reduced with the increase of solid particle size. As a result of Ni grain refinement, incorporating of TiO₂ particles, and the improved uniformity of incorporated TiO₂ particles in the Ni matrix, highest hardness at 1274 HV was obtained in the Ni-TiO₂ composite with the most uniform TiO₂ particle distribution using smallest TiO₂ nanoparticle.

In chapter 5, micro-mechanical properties and the sample size effect in Ni-TiO₂ composites prepared by co-electrodeposition with supercritical CO₂ emulsified electrolyte were evaluated by micro-compression tests. The average grain sizes of the Ni matrix in the conventional Ni-TiO₂ composite films and SC-CO₂ Ni-TiO₂ composite films were 23.6 nm and 9.7 nm, respectively. The TiO₂ content was 3.83 wt% for the conventional Ni-TiO₂ composite films and 4.05 wt% for the SC-CO₂ Ni-TiO₂ composite films. The strengths of the SC-CO₂ Ni-TiO₂ pillars were all much larger than those of the conventional Ni-TiO₂ pillars. The yield strength of a SC-CO₂ Ni-TiO₂ having the dimensions of 7.5 μm $\times$ 7.5 μm $\times$ 15 μm was 3.4 GPa. The value was about 3 folds of the yield strength of a conventional Ni-TiO₂ pillars having the same sizes. Regarding the sample size effect, the strength was independent of the sample size for the SC-CO₂ Ni-TiO₂ 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-CO₂ assisted co-electrodeposition in fabrication of Au matrix composite materials, Conventional co-electrodeposition of Au-TiO₂, a potentially alternative material of Si for the proof mass in micro-accelerometer, was conducted. Effects of the TiO₂ 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 TiO₂ 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.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

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