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種別(和文)	論文要旨
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（博士課程）
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論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	材料 系 材料 コース	申請学位（専攻分野）： Academic Degree Requested	博士 （工学） Doctor of Engineering
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

To develop novel Ti-based superelastic alloys which exhibit the large lattice deformation strains near the room temperature for practical biomedical applications, the effects of Cr and Sn additives on the lattice deformation strain, martensitic transformation temperature, and deformation behavior of Sn-rich Ti-Cr-Sn alloys were systematically explored in a wide range of alloy compositions: Ti-(1.5~4.0)Cr-(6.0~9.0)Sn (mol%). The lattice deformation strain values ($|\eta_1|$, η_2, and η_3) were calculated based on the lattice parameters of the martensite α″ and parent β phases. The rates of change of η_2 with Cr and Sn content were determined: −0.79%/mol% Cr and −0.56 %/mol% Sn, respectively. The reverse martensitic transformation temperature (A_s and A_f) changed with Cr and Sn content at rates of approximately −190 K/mol% Cr and −141 K/mol% Sn, respectively. The deformation behavior of Ti-Cr-Sn alloys at room temperature (RT: 298 K) changed from SME to SE with increasing Cr and Sn contents. Especially, Ti-2.5Cr-8.5Sn, Ti-3.0Cr-7.5Sn, Ti-3.0Cr-8.0Sn, Ti-3.5Cr-7.0Sn, and Ti-4.0Cr-6.5Sn alloys exhibited SE at RT and possessed large η_2 values that exceeded 6.32%. Moreover, it was revealed that the addition of Cr and Sn can decrease the martensitic transformation temperature considerably without significant reduction of lattice deformation strain in comparison with other additional elements in the literature.

The superelastic properties of the solution-treated Ti-2.5Cr-8.5Sn, Ti-3.0Cr-7.5Sn, Ti-3.5Cr-7.0Sn, and Ti-4.0Cr-6.5Sn superelastic alloys were systematically characterized and compared in terms of their microstructure, lattice deformation strain and superelastic behavior including critical stress for slip and shape recovery strain. It was found that all the alloys consist of single β-phase at RT by X-ray diffraction analysis, and that the formation of athermal ω phase observed by transmission electron microscopy seemed to be suppressed with decreasing Cr contents and increasing Sn contents. Mechanical tests revealed that the larger superelastic recovery strains (ε_{SE}) over 3.6% were obtained in Ti-2.5Cr-8.5Sn and Ti-4.0Cr-6.5Sn alloys than those in the others. Although there was no significant difference in martensitic transformation temperature and critical stress for slip deformation (σ_{CSS}) between Ti-2.5Cr-8.5Sn and Ti-4.0Cr-6.5Sn alloys, the highest value of ε_{SE} for 4.0% was obtained in Ti-4.0Cr-6.5Sn alloy due to their well-developed $<011>_\beta$ texture component. Moreover, both Ti-2.5Cr-8.5Sn and Ti-4.0Cr-6.5Sn alloys exhibited the almost perfect SE and maintained lager than 4.5% shape recovery strain after 100 cycles of repetitive loading-unloading tensile tests to keep a maximum applied strain of 5.0%. The superior SE behaviors were due to their considerably high values of η_2, ε_{SE}, and σ_{CSS} than the previously reported β-Ti SE alloys. Finally, from the viewpoint of Sn content, Ti-4.0Cr-6.5Sn alloy with lower Sn content is judged to be the best superelastic alloy in the Ti-Cr-Sn ternary system.

To optimize the heat-treatment condition for the achievement of superior SE in Ti-4.0Cr-6.5Sn alloy, the effects of solution treatment condition on microstructure characteristics and superelastic properties were systematically investigated by changing solution treatment temperature and duration time. Regardless of texture distribution, the higher value of ε_{SE} was obtained when the solution-treated Ti-4.0Cr-6.5Sn alloy possess the relatively high values of σ_{CSS} / σ_{SIMT} and $\varepsilon_{CSS} - \varepsilon_{SIMT}$. Moreover, the optimized solution treatment condition was determined to be temperature of 1213 K and time of 3.6 ks for Ti-4.0Cr-6.5Sn alloy and the highest ε_{SE} value of 4.5% was obtained due to its highest values of σ_{CSS} / σ_{SIMT} and $\varepsilon_{CSS} - \varepsilon_{SIMT}$.

To obtaining the improved mechanical properties, the formation of fine-dispersed Y_2O_3 particles was attempted through the reaction between yttrium (Y) and solute oxygen (O) for the effective β-grain refinement using Ti-2.5Cr-8.5Sn alloy. Then, the effects of Y addition on microstructure, martensitic transformation temperature and mechanical properties were investigated by varying Y content up to 1mol%. Since element Y possesses the high affinity with O and low solubility in Ti alloys, Y_2O_3 oxide was preferentially formed by consuming the residual oxygen in the matrix through the scavenging effect when Y content was ranged up to 0.15 mol%. Then, the β-grain size became effectively smaller with Y content due to the well-dispersed Y_2O_3 oxides. When Y content exceeded 0.15 mol%, Y_5Sn_3 intermetallic phase was also formed in addition to Y_2O_3 oxides. The deformation behavior changed from SE to SME at RT with increasing Y content. The change in deformation behavior is considered by the increase in martensitic transformation temperature, since Y addition absorbs and consumes O and Sn atoms in the β matrix. As for the effect on mechanical properties, the ultimate tensile strength was significantly raised from 788 MPa (Y-free) to 1120 MPa (0.15Y addition). This improvement is judged to be achieved not only by the effective β-grain refinement but also dispersion strengthening of Y_2O_3 oxide particles.