論文 / 著書情報
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題目(和文)	組成的に均一および勾配を持つAuTiCo生体用形状記憶合金のマルテンサイト変態挙動に関する研究
Title(English)	Study on Martensitic Transformation Behavior of AuTiCo Biomedical Shape Memory Alloys with Homogeneous and Gradient Chemical Compositions
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Thesis outline

The development of AuTi-based shape memory/superelastic alloys has been launched due to the possibility of Ni-hypersensitivity and not enough X-ray visibility of NiTi alloys. To utilize AuTi as a biomedical material, its martensitic transformation start temperature (M_s) of 880 K must be close or lower than the human body temperature. Co addition is selected to reduce M_s since AuTi and CoTi form a continuous solid solution of (Au, Co)Ti in the AuTi-CoTi pseudobinary system. Beside, M_s becomes around the body temperature by 18-19 mol% Co addition. However, room temperature (RT) superelasticity is not recognized in stoichiometric Au-50Ti-18Co alloy and the AuTiCo ternary alloys are brittle when the Co exceeds 18 mol% while M_s still higher than RT. Therefore, the lowering of M_s without deterioration of mechanical properties is strongly required for the RT superelasticity. It has been reported that the compositional deviation from the stoichiometry is effective to reduce M_s in the NiTi and AuTi alloys. Therefore, the AuTi-18Co alloys with offstoichiometric compositions ((Au, Co):Ti ≠ 50:50) are focused and effect of Ti content on martensitic transformation and mechanical properties of AuTiCo alloys with homogeneous chemical compositions is the first objective in this study.

In the field of research and development for exploring new materials, the discovery must face with the high cost and time-consuming processes, then combining diffusion couple (DC) and in situ optical microscope (OM) technique has been established for obtaining composition dependent martensitic transformation temperature. However, the accurate measurement of the martensitic transformation temperature which derived from this technique is still concerned. In the present study, a construction of a new evaluation method of martensitic transformation temperature of AuTiCo alloy with a composition gradient specimen under a hypothesis of constraint from the surrounding untransformed area is the second objective in this study.

It was clearly seen that the compositional deviation from the stoichiometry in both Ti-poor and Ti-rich sides was a crucial way not only to stabilize the B2 parent phase and also reduce M_s in the AuTiCo system. Moreover, high transformation strain over 6 %, the sufficient low M_s and the RT superelasticity were evaluated in the Ti-rich AuTi-18Co alloy.

The elastic constraint from the surrounding untransformed area was considered as the origin of the suppression in martensitic transformation temperature in the AuTiCo alloy with composition gradient specimen. This hypothesis successfully elucidated for the progress of martensitic transformation using the AuTiCo alloy by introducing a concept of vertical trench. These vertical trenches were defined as the trenches perpendicular to the composition gradient which fabricated by a focused ion beam (FIB) technique and they were utilized to control the length of the surrounding untransformed area as well as to minimize the elastic constraint through a combining of DC and in situ OM method. It was also seen by an in situ OM observation that the DC specimen with the vertical trenches revealed the martensitic transformation temperature near coincided with the bulk specimen with the similar chemical composition. Besides, the elastic constraint was found to affect the martensitic transformation temperature when the length of the surrounding untransformed area was between 50 μm and 200 μm. The additional strain energy caused by the elastic constraint between these lengths was quantitatively calculated as 105 J/mol. By using the first and second laws of thermodynamics, the correlation between this extra addition energy and the shift of martensitic transformation temperature was proposed and this energy was responsible for the shift of transformation temperature.

In conclusion, the offstoichiometric composition is an effective way for not only the decrease in M_s but also the presence of the RT superelasticity in the AuTiCo alloys. Furthermore, the new method for efficiently obtaining the composition dependent of the accurate martensitic transformation temperature in the composition gradient specimen was introduced as the composition gradient specimen with the vertical trenches. This new method could be applicable for not only the AuTiCo system but also the composition gradient specimen with thermoelastic martensitic transformation in the other alloy systems.