

論文 / 著書情報  
Article / Book Information

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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出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第11106号, 授与年月日:2019年3月26日, 学位の種別:課程博士, 審査員:細田 秀樹,舟窪 浩,三宮 工,木村 好里,曾根 正人
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第11106号, Conferred date:2019/3/26, Degree Type:Course doctor, Examiner:,,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

## 論文要旨

THESIS SUMMARY

専攻 : Innovative and  
Department of Engineered Materials 専攻  
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申請学位 (専攻分野) : 博士 (Engineering)  
Academic Degree Requested Doctor of  
指導教員 (主) : Professor  
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### 要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

The possibility of Ni-hypersensitivity and low X-ray visibility of NiTi alloys have stimulated the developments of AuTi-based shape memory 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. Then, Co addition is focused to reduce  $M_s$  since AuTi and CoTi form a continuous solid solution of (Au, Co)Ti. 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 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 required. 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 are focused and the 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. The present study is consisted of the following six chapters;

#### Chapter 1: General Introduction

The overviews of AuTi-based shape memory alloys, the combinatorial studies related with the DC material which is used for studying composition dependence of martensitic transformation temperature are mentioned. The background, motivation and objective of the present study are also given here.

#### Chapter 2: Effect of Ti Content on Martensitic Transformation and Mechanical Properties of AuTiCo Alloys with Homogeneous Chemical Compositions

The effect of Ti content in AuTi-18Co mol % alloys on the phase constitution, martensitic transformation temperature, mechanical and superelastic properties was clarified. The stabilization of B2 parent phase and the sufficient low martensitic transformation temperature for the medical applications were obtained at the offstoichiometric composition. The Ti-rich AuTi-18Co alloy exhibited RT superelasticity with superelastic shape recovery strain of 3.5 %.

#### Chapter 3: Diffusion Behavior and Phase Relationship of AuTi and CoTi Intermetallic Compounds

The phase reaction, diffusion behavior of a AuTi/CoTi diffusion coupled specimen at

various heat-treatment temperatures. Two intermetallic compounds of  $(\text{Au,Co})\text{Ti}_3$  and  $(\text{Au,Co})_2\text{Ti}$  were formed near interface when heat-treated at 1173 K and 1273 K, and only  $(\text{Au,Co})\text{Ti}_3$  existed at 1373 K. The apparent activation energy for the growth of the diffusion layer estimated was 127 kJ/mol.

#### Chapter 4: A New Evaluation Method of Martensitic Transformation Temperature using AuTiCo Alloy with Gradient Chemical Composition

The elastic constraint from the surrounding untransformed area was considered as the origin of the suppression in martensitic transformation temperature in 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. It was also seen that the DC specimen with the vertical trenches revealed the martensitic transformation temperature near coincided with the bulk specimen. Then, a new evaluation method for obtaining more accurate martensitic transformation temperature was successfully proposed as a DC specimen with vertical trenches.

#### Chapter 5: A Consideration of Martensitic Transformation Behavior using AuTiCo Alloy with Gradient Chemical Composition

By controlling the length of the surrounding untransformed area, the elastic constraint was affected the martensitic transformation temperature when the length was between 50  $\mu\text{m}$  and 200  $\mu\text{m}$ . The additional strain energy caused by the elastic constraint between these lengths was estimated 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 of 48 K in the composition gradient specimen.

#### Chapter 6: General conclusions

Important conclusions in each chapter and new findings of the present study are given.

In summary, the offstoichiometric composition is effective to obtain the sufficient low  $M_s$  temperature and 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 also be applicable for the composition gradient specimen with thermoelastic martensitic transformation in the other alloy systems

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。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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