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P024

DEFORMATION AND FATIGUE PROPERTIES OF NITROGEN ION IMPLANTED TiNi SHAPE MEMORY ALLOY

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1. Introduction

Shape memory alloy (SMA) is expected to be applied as intelligent materials since it shows the unique characteristics of the shape memory effect (SME) and superelasticity (SE). Most SMA elements with using these characteristics perform cyclic motions. In these cases, fatigue of SMA is one of the important properties in view of evaluating functional characteristics as SMA elements. Fatigue properties of SME and SE are complex since they depend on stress, strain, temperature and time which are related to the martensitic transformation (MT). If SMA is implanted by high energy ions, the thermomechanical properties may change, resulting in long fatigue life. In the present paper, the nitrogen ion implantation was applied to modify TiNi SMA tape surface and the influence of implantation treatment on the tensile deformation and bending fatigue properties is investigated.

2. Transformation temperature

The TiNi SMA tape of a width of 2.5 mm and a thickness of 1.0 mm was ion-implanted on both surfaces from two opposite directions by nitrogen ion beam with acceleration energy of 50 keV. The total doses of implanted ion are 8×10^{16}, 3×10^{17} and 2.5×10^{18} J/cm^2. The DSC thermograms for non-implanted and ion-implanted with 2.5×10^{18} J/cm^2 tapes are shown in Fig. 1. If the nitrogen ion was implanted, the transformation temperatures R_s, R_f, A_s and A_f increase a little.

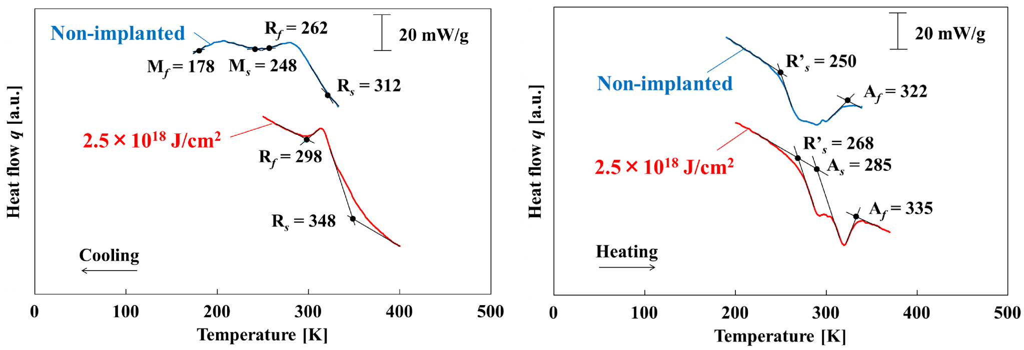

Fig. 1. DSC thermograms for two kinds of tapes with non-implanted and 2.5×10^{18} J/cm^2.

3. Tensile deformation property

The stress-strain curves of non-implanted and ion-implanted with 2.5×10^{18} J/cm^2 tapes obtained by the tension test at room temperature are shown in Fig. 2. The stress-strain curve with non-implanted tape draws a hysteresis curve during loading and unloading, showing the SE. The curve with 2.5×10^{18} J/cm^2 shows the partial SE. As observed in Fig. 1, if the nitrogen ion is implanted, the transformation temperatures increase a little. Both upper and lower yield stresses therefore decrease and the partial SE appears in place of the SE.

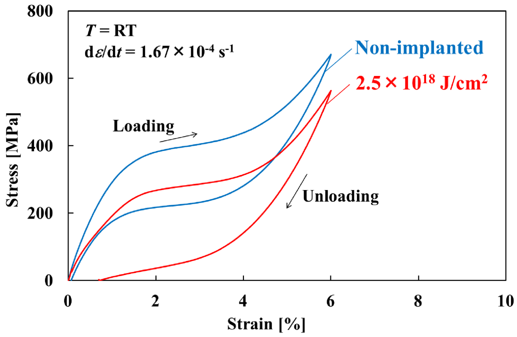

Fig. 2. Stress-strain curves of two kinds of tapes obtained by the tension test at room temperature.

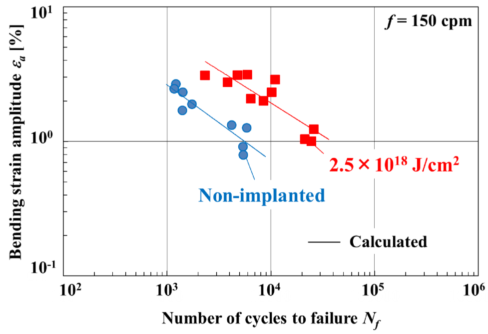

Fig. 3. Relationships between maximum bending strain and the number of cycles to failure obtained by the alternating-plane bending fatigue test.

4. Bending fatigue property

The relationships between the maximum bending strain and the number of cycles to failure for two kinds of tapes obtained by the alternating-plane bending fatigue test at room temperature are shown in Fig. 3. The larger the maximum bending strain, the shorter the fatigue life is. If the nitrogen ion is implanted, the bending fatigue life becomes longer.

5. Fatigue fracture surface

Figure 4 shows SEM photographs of a fracture surface of two kinds of tapes obtained by the alternating-plane bending fatigue test. In Fig. 4, F_c denotes the initiation point of the fatigue crack. In the case of the non-implanted tape, the crack nucleates at a certain point F_c in the central position of the surface and propagates towards the center in an ellipsoidal pattern. In the case of the ion-implanted with 2.5×10^{18} J/cm^2 tape, the crack nucleates at a corner of the tape and propagates towards the center and along the surface of the tape with the higher speed of progression.

a) b)

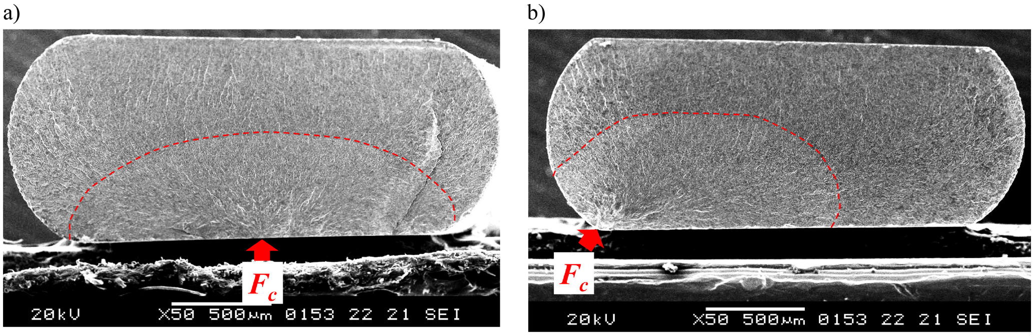

Fig. 4. SEM photographs of a fracture surface of two kinds of tapes obtained by the alternating-plane bending fatigue test: a) non-implanted, b) implanted with 2.5×10^{18} J/cm^2.