CORROSION FATIGUE STRENGTH OF THERMAL NITRIDED TINI SHAPE MEMORY ALLOY WIRE

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1. Introduction

A TiNi shape memory alloy (SMA) has some advantages compare to other series of SMAs such as large recovery strain, long fatigue life, better biocompatibility, etc. Therefore, the TiNi SMA is commonly used as actuators and medical devices. In the case of practical use of the TiNi SMA into these devices, it is important to grasp a corrosion resistance and corrosion fatigue strength of the material. A few researchers have investigated how to improve the corrosion resistance of the material [1], however, no study has revealed the fatigue properties of the TiNi SMA in severe conditions, such as in seawater or blood, yet. In this study, we attempt to clarify the corrosion fatigue life of the TiNi SMA and enhance it by means of a thermal nitridation (TN) treatment which is able to produce a thin passive layer on the surface of the material.

2. Experimental conditions and procedures

The material used in the study is a 0.7 mm diameter TiNi SMA wire (Ti-49.7 at% Ni) manufactured by Furukawa Techno Material Co., Ltd. We carried out the following procedure for TN treatment as shown in Fig. 1. First, the as-received (as-drawn) material was mechanically polished to remove a surface oxide film by abrasive wheels and a buffing compound. Second, the polished material was degreased by an ultrasonic washer. Then the degreased material was heat-treated in a gas substitution electrical furnace filled with pure N_2 gas for 1 h at 673 K at a gauge pressure of 0.1 MPa. The material was then allowed to cool inside the furnace. We also prepared a heat-treated (HT) material that was produced by only conventional shape memory heat treatment in air under the same condition as the TN process except for the atmosphere and a material that was removed the film generated via the HT. The material produced by this process is hereafter referred to as the HT-P material.

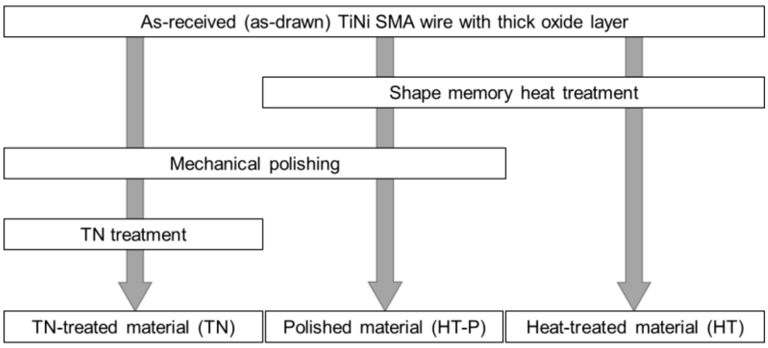

Fig. 1 Fabrication process of each material

We assessed the corrosion resistance of the materials by anodic polarization curves. In the experiment, we used a counter electrode made of platinum and a saturated calomel electrode as a reference. The anodic polarization curves were obtained by an automatic polarization system (HSV-110, Hokuto Denko Corporation), which can apply electrical potential at a scanning rate of 10 mV/min. A 3%-NaCl water solution was used as the electrolyte.
We also investigated the corrosion fatigue life of each material by rotating bending fatigue tests in 10%-NaCl water solution under a frequency of 100 cpm at room temperature.

3. Results and discussion

Figure 2 shows the anodic polarization curves of the materials. This figure includes results of pure Ti and 316L stainless steel which are common materials as medical devices. It is clearly found that the potential of the TN material is much higher than that of the HT-P, 316L, and HT material especially in the early stage of the corrosion. Not only that, the TN material has the corrosion resistance comparable to the pure Ti. Obviously, this high resistance is the effect of the passive layer consisted of Ti nitride generated by the TN process.
Fatigue life curves of the TN, HT-P, and HT materials obtained by the rotating bending fatigue tests in the 10%-NaCl water solution are shown in Fig. 3. The fatigue lives of the TN and HT-P materials are higher than that of the HT material because the surface roughness of these materials is much lower compare with that of the HT material owing to the mechanical polishing. In the low strain region (the strain range of above 1.5%), the TN material shows the long fatigue life even in the severe environment. Although we presume that such long fatigue life of the TN material is achieved by the presence of the thin passive layer, clarifying the influence of the passive layer on the corrosion fatigue life for the TiNi SMA is our future task.

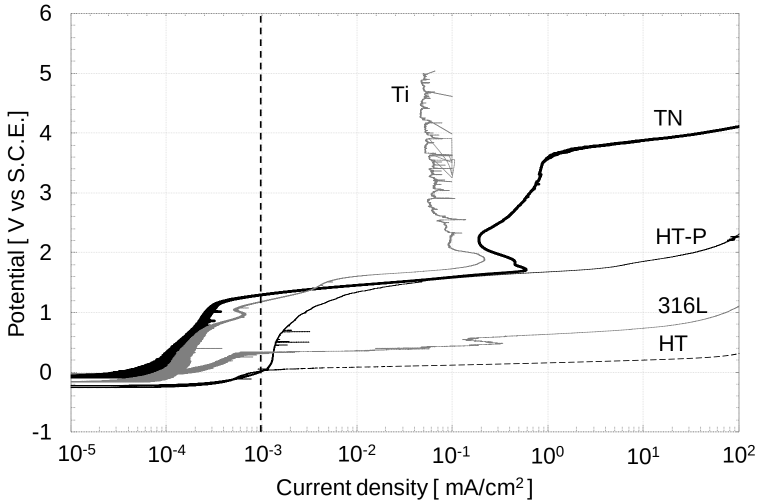

Fig. 2 Anodic polarization curves for each material

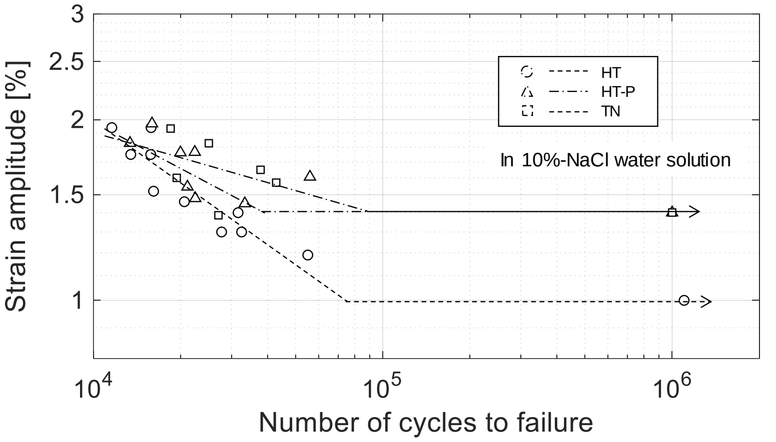

Fig. 3 Fatigue life curves for each material

Acknowledgments The authors acknowledge the financial support of The Science Research Promotion Fund.

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