ICEM21

21st International Conference on EXPERIMENTAL MECHANICS

6-11 July 2025
Bologna

BOOKS OF ABSTRACTS

Società Editrice ESCULAPIO

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INHOMOGENEOUS TENSILE DEFORMATION OF NITROGEN-ADDED Ti-Nb BASED SHAPE MEMORY ALLOYS

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1. Introduction

Ti-Nb based shape memory alloys (SMAs) exhibit shape memory effect or superelasticity due to the phase transformation from body-centered cubic β phase to orthorhombic α″ martensite [1, 2]. The addition of interstitial alloying elements, such as oxygen and nitrogen, can change the stress-strain response of these alloys [3, 4]. It is due to the formation of randomly distributed nanodomains. This strategy has been used to achieve and tailor specific properties of Ti-Nb SMAs, including superelastic deformation or invar-like behavior [4]. However, this class of SMAs has been seldom studied by means of digital image correlation (DIC), which can deepen the knowledge about the kinetics of deformation. The analysis of thermomechanical behavior of Gum Metal (Ti-23Nb-0.7Ta-2Zr-1.2O, at. %) under tensile loadings using infrared thermography and DIC did not present any local effects due to the high content of oxygen [5]. However, recent investigation of oxygen-added Ti-Nb SMAs in tension using DIC showed that the strain fields of these alloys are very inhomogeneous during the initial loading [6]. The objective of this study is to analyze and compare deformation fields of Ti-25Nb and Ti-25Nb-0.3N SMAs captured at selected stages of tension using DIC.

2. Materials and methods

The alloys were prepared by the Ar arc melting method using pre-melted sponges of Ti, pellets of pure Nb. The nitrogen concentrations of the alloys were adjusted by addition of TiN powder. The ingots were sealed in a vacuumed quartz tube and homogenized at 1273 K for 120 min with subsequent air-cooling. Then the ingots were cold-rolled with a reduction in thickness of 95%. Specimens for tensile tests were cut using an electro-discharge machine. Then, the specimens were solution-treated at 1173 K for 30 min in an Ar atmosphere, followed by water quenching. The damaged surface was removed by chemical etching at each step of the fabrication process. The surface of each specimen was first covered with soot and then small dots of white paint were sprayed onto the soot layer to obtain an adequate pattern for DIC. Displacement-controlled load-unload tensile tests of the SMAs specimens were carried out using an MTS 858 testing machine at room temperature. Maximal displacement of 0.35 mm and displacement rate of 0.12 mm/s were used. The gauge part of each specimen was 4 mm × 6 mm × 0.5 mm. Taking into account the specimen's geometry, an average strain rate of $2 \cdot 10^{-2}$ s^{-1} was applied. The deformation process of each specimen was monitored by a visible range (0.4 μm – 1 μm) sCMOS PCO Edge 5.5 camera for further DIC analysis.

3. Results and conclusions

True stress vs. true strain curves of Ti-25Nb and Ti-25Nb-0.3N SMAs under load-unload tension with ε_{yy} fields captured at selected stages of the deformation process are presented in Fig. 1(a) and 1(b), respectively. During the tension loading, the Ti-25Nb SMA exhibited a Lüders-type deformation via a development of macroscopic martensite bands at about 55^{o} from the loading direction, which was clearly observed in ε_{yy} fields. The Ti-25Nb-0.3N SMA showed a different kind of deformation in a form of narrow bands with higher values of strain, which were perpendicular to the loading axis.

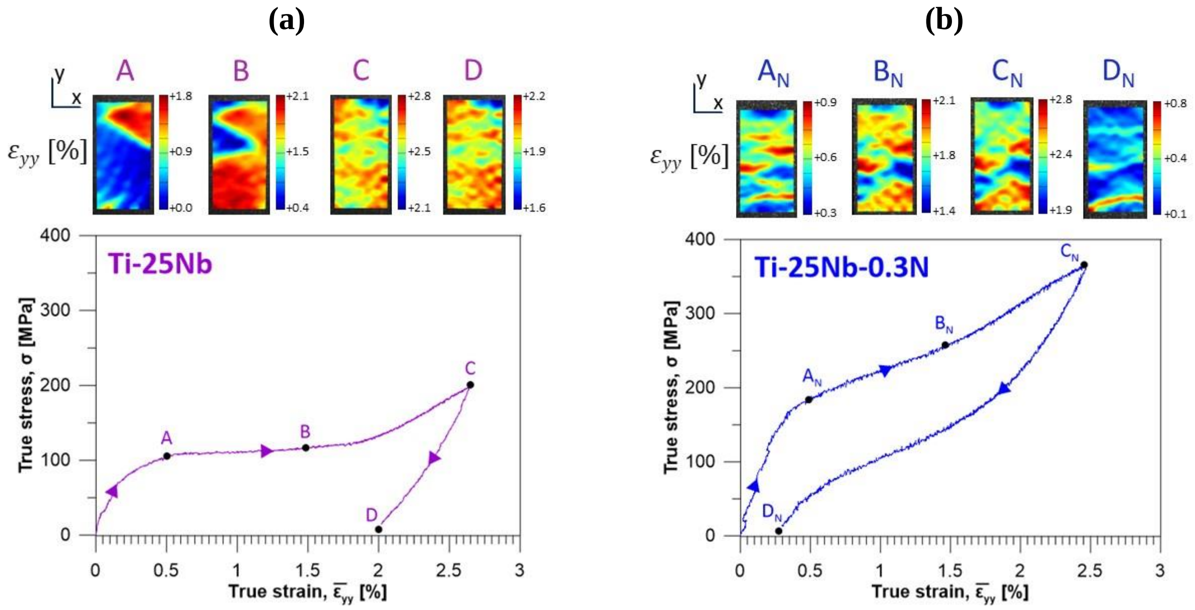

Fig. 1. True stress vs. true strain curves of (a) Ti-25Nb and (b) Ti-25Nb-0.3N SMAs under load-unload tension with ε_{yy} fields captured at selected stages of the deformation process.

4. Acknowledgements

Karol M. Golasiński acknowledges the support of the Japan Society for the Promotion of Science (JSPS) Postdoctoral Fellowship (ID No. P20812) and the National Science Centre, Poland through the Grant 2023/48/C/ST8/00038.

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