3 Abstracts: Materials engineering

3.1 A phase-field study of the energy and morphology of martensite–twinned martensite interface in CuAlNi shape memory alloy

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When a single-crystal bar of CuAlNi shape memory alloy (SMA) is under the temperature gradient, a special microstructure (known as λ-microstructure) is observed (Figure 3.1.1(a, b)). This microstructure involves two macroscopic interfaces between austenite and twinned martensite and two between martensite and twinned martensite. At the micro scale of martensite–twinned martensite interface, needle-like twins are revealed as depicted in Figure 3.1.1.(c)[4].

This study[5] aims to conduct a numerical investigation employing phase-field approach, with a primary focus on simulating the morphology of the transition layer and analyzing its energy measures. More specifically, the effects of twin spacing and twin volume fraction on the morphology of transition layer, elastic strain and interfacial energy quantities are considered. Our simulation results demonstrate the tapering and bending in the needle-shaped microstructures which are qualitatively in agreement with literature[4]. Moreover, in certain twin volume fractions, twin branched morphology occurring as a result of minimize the total free energy stored in the microstructure.

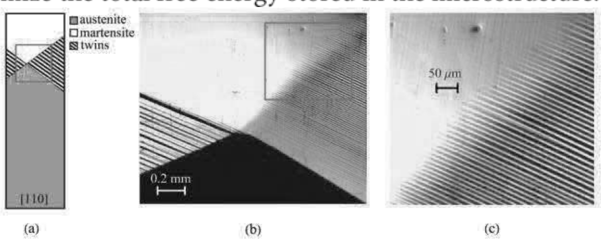

Figure 3.1.1. (a) Schematic of λ-microstructure on a [110] plane in single-crystal bar of CuAlNi, (b) close-up view of the λ-microstructure, (c) magnified view of needle shaped microstructure at the martensite–twinned martensite interface[4]

[4] H. Seiner, O. Glatz, M. Landa, A finite element analysis of the morphology of the twinned-to- detwinned interface observed in microstructure of the Cu–Al–Ni shape memory alloy, Int. J. Solids Struct. 48 (2011) 2005–2014

[5] S. Amini, M. Rezaee-Hajidehi, S. Stupkiewicz, Energy and morphology of martensite–twinned martensite interface in CuAlNi shape memory alloy: A phase-field study, Computational Materials Science 230 (2023) 112472

3.2 Continuum model of twin branching in shape memory alloys

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The presence of a branched microstructure or the refinement of twin spacing near the macroscopic austenite-twinned martensite (A-MM) interface in shape memory alloys has been observed in numerous experiments[6]. This morphology forms as a means to reduce the elastic strain energy localized at macroscopic A-MM interface at the cost of increasing the interfacial energy. Recently, Seiner et al.[7] introduced a discrete model of branching, focusing on estimating the elastic strain energy and interfacial energy of each branched microstructure.

The main objective of the present study is to introduce a simplified continuous energy formulation based on the model proposed by Seiner et al.[7]. Our findings reveal that the results of our model are in quantitative agreement with the literature over a wide range of input parameters[7].

[6] C. Zhang, G. Qin, S. Zhang, X. Chen, Y. He, Hysteresis effect on austenite-martensite interface in Ni-Mn-Ga single crystal, Scripta Materialia 222 (2023) 115029

[7] H. Seiner, P. Plucinsky, V. Dabade, B. Benesova, R. D. James, Branching of twins in shape memory alloys revisited, J. Mech. Phys. Solids 141 (2020) 103961