

Studies on the functional degradation of Fe–Mn–Al–Ni shape memory alloy under compression using acoustic emission measurements

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The functional degradation of the superelastic behavior of Fe-Mn-Al-Ni shape memory alloy was studied by in situ acoustic emission (AE) measurements under compressive loading during ten superelastic cycles. The stress-induced martensitic phase transformation was studied on a [00-1] orientated single crystal. The acoustic investigations were corroborated by optical microscopy, employing video imaging, and transmission electron microscopy. The analysis of acoustic emissions recorded during repeated loading and unloading cycles revealed two categories of AE signals that differed by their characteristics in time and frequency domains. These two distinct types of AE signals were related to two underlying mechanisms: (i) the nucleation and reverse transformation of stress-induced (twinned) martensite, and (ii) the lateral growth and shrinkage of one dominant martensite variant and related dislocation activities, respectively. In addition, an asymmetry in the AE activity during forward and reverse transformation during mechanical loading and unloading was detected. In particular, an unexpected high AE activity was observed during the superelastic unloading of martensitic microstructure from the point of maximum load/strain. This effect was attributed to the reverse transformation of small, tiny areas of martensite as well as to unpinning and annihilation effects related to dislocations.