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## Two types of martensitic phase transformations in magnetic shape memory alloys by in-situ nanoindentation studies

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### ABSTRACT

Ni based magnetic shape memory alloys (MSMAs) have broad applications in actuators and MEMS devices. Two-stage stress induced martensitic phase transformation, a widely observed phenomenon in these alloys, is described conventionally as a first stage L21 (austenite)-to-10M/14M (M: modulated martensite) transition, followed by a second stage 14M-to-L10 (tetragonal martensite) transformation at higher stresses. Here we show, for the first time via in-situ nanoindentation on single crystalline  $\text{Ni}_{54}\text{Fe}_{19}\text{Ga}_{27}$  alloy, that a reversible L21-to-10M/14M transformations took place at lower stress. However at higher stress, an irreversible transition from residual L21 to L10 martensite (a second type of phase transformation) occurred. Furthermore phase fronts propagate gradually during the L21-to-10M/14M transformation, whereas L10 is abruptly emitted in a jerky style during the 14M-to-L10 transformation. Detailed examination of crystal structure suggests that a direct transition from 14M to observed L10 is crystallographically forbidden in the current loading condition. This study provides new perspective for understanding of stress induced various types of phase transformations in MSMAs. This research is funded by NSF-CMMI under grant no. 1129065.