On the cofactor conditions and further conditions of supercompatibility between phases

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Abstract

In this paper we improve the understanding of the cofactor conditions, which are particular conditions of geometric compatibility between austenite and martensite, that are believed to influence reversibility of martensitic transformations. We also introduce a physically motivated metric to measure how closely a material satisfies the cofactor conditions, as the two currently used in the literature can give contradictory results. We introduce a new condition of super-compatibility between martensitic laminates, which potentially reduces hysteresis and enhances reversibility. Finally, we show that this new condition of super-compatibility is very closely satisfied by $Zn_{45}Au_{30}Cu_{25}$, the first of a class of recently discovered materials, fabricated to closely satisfy the cofactor conditions, and undergoing ultra-reversible martensitic transformation.

Keywords: Martensitic phase transformation, Compatibility, Cofactor conditions, Microstructures, Reversibility.

1 Introduction

The cofactor conditions are particular conditions of supercompatibility between phases in martensitic transformations. These include, among other conditions, that the middle eigenvalue λ_2 of the martensitic transformation matrices is equal to one, which has formerly been shown to influence the hysteresis of martensitic transformations (see e.g., [19]). The cofactor conditions allow finely twinned martensitic variants to be compatible with austenite, independently of the volume fraction, across a plane. Due to this special compatibility, the cofactor conditions have been conjectured to influence reversibility of the phase transitions, first in [13] and later in [5]. The fabrication of $Zn_{45}Au_{30}Cu_{25}$, the first material closely satisfying the cofactor conditions, partially confirms this conjecture (see [17]). Indeed, both the latent heat of the transformation and the critical temperature in $Zn_{45}Au_{30}Cu_{25}$ do not change significantly over 16000 thermal cycles (see [17]). Furthermore, the hysteresis loop in this new material seems to be only very slightly affected after 10^5 cycles of uniaxial compressive loading (see [15]). After $Zn_{45}Au_{30}Cu_{25}$, other alloys closely satisfying the cofactor conditions have been fabricated (see [6] and [9]), whose hysteresis curve does not significantly

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