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Disconnections and other defects associated with twin interfaces

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The general topological model for interfacial defects is reviewed and expanded, and the role of these defects in the coupled shear - migration of interfaces is explored. We focus on twinning in hexagonal metals for many defect examples. The definition of shuffles within the topological model is presented. The concept of partitioning of the rotational component of elastic distortions at a grain boundary or interphase interface has recently been elucidated. This work shows that rotational coherency has an important role in twinning. The role of disconnections in type II twins is presented.

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1. Introduction

The principal objective of the present work is to discuss the structure of interfaces and mechanisms of interface motion within the Topological Model (TM) [1–5]. A list of such commonly used acronyms is given in Appendix E. The basis for the TM is the topological theory that describes the crystallography of bicrystal interfaces in terms of dichromatic patterns [1,2]. Here, we do not emphasize formal crystallography, briefly reviewed in Appendix A, but emphasize physical interpretations in the TM, developed in terms of circuits in Appendix B. We concentrate on interfaces which exhibit terrace – defect structures: coherent terraces have relatively low interfacial free energy, and any coherency strains arising are removed at long-range by superposed arrays of line-defects [6,7]. Under the constraint that coherency stresses are imposed on both crystals, the coherent terrace would be a singular interface corresponding to a cusp in a Gibbs-Wulff plot of interfacial free energy as a function of interface orientation. The presence of such a cusp is the key underlying criterion for the presence of terrace structures. The defects that relax the coherency strains are designated interfacial dislocations, or disconnections if they also exhibit step character [6,8]. Line defects with disclination character [9–13] can also be present, for example at junctions between interface facets [1]. The disclination structures, recently studied [14–16], have received little attention and are emphasized here. Interfacial dislocations have an important function in accommodating misfit at static interfaces, and in this role are typically referred to as "misfit" dislocations [17,18]. Disconnections can also fulfil this role. However, an additional function of disconnections is that motion along an interface produces both plastic deformation and interface migration simultaneously. The latter two functions are implicit in the mechanistic interpretation [19–22] of the Phenomenological Theory of Martensitic Crystallography (PTMC) [23–25], and the dual dislocation-step nature of the defects was qualitatively considered by several groups, as reviewed in [3]. The two functions were formally defined in the TM [4,5], see in particular Appendix A. Consequently, the TM is key in explaining displacive phase transformations and coupled shear-migration at grain boundaries [26]. Twinning is an important example of coupled motion [27–31], and, in this article, for examples, we focus on twinning in hexagonal close-packed (*hcp*) metals where twinning is a major deformation mode [32], although other interfaces are also mentioned. Additional extended twin defects with pure step character are also considered.

Twinning disconnections or twinning dislocations (TDs) and the role of shuffling in twinning are considered in the review by Christian and Mahajan [32]. The formal phenomenology of twins has also been reviewed recently in [33], as have the