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Defect-interface interactions

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ABSTRACT

Nanostructured materials contain an extremely high density of interfaces. The properties of these materials when exposed to extreme conditions of radiation dose, stress, deformation, or temperature are largely determined by defect-interface interactions. In this article, we review the present understanding of defect-interface interactions in single-phase and two-phase metal and oxide nanocomposites, emphasizing how interface structure affects interactions with point, line, and planar defects. We also review the crystallographic, chemical, and morphological stability of interfaces in different extreme environments: irradiation and mechanical deformation. Our current understanding of these topics prompts new questions that will maintain interfaces in crystalline solids at the frontier of materials research for years to come.

Contents

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1. Introduction

Interfaces in solid materials are boundaries that separate crystals of the same structure and chemistry but different orientation (grain boundaries) or crystals of different structure and/or chemistry as well as orientation (interphase boundaries or heterophase interfaces). The influence of interfaces on the mechanical properties of polycrystalline materials is critical in materials design and lifetime predictions. Hirth [1] in his seminal 1972 review noted that "*if one excludes single crystal research, one could claim that the balance of the field of metallurgy relates to interfacial properties*." These opinions are as appropriate today as in the 1970s.

Since the formative work of Chalmers [2] in 1948 illustrating the effect of grain boundaries on the plastic deformation of crystalline materials, both grain boundaries (homophase interfaces) and interphase interfaces in polycrystals have been shown to play a fundamental role in material properties, such as strength, fracture, work hardening, and damage evolution under irradiation and shock.