

STRUCTURE, PHASE TRANSFORMATIONS, AND DIFFUSION

Phase Transformations Induced by High Pressure Torsion

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Abstract—High pressure torsion (HPT) causes a number of phase transformations. The competition between the processes of formation and decomposition of supersaturated solid solution is of particular interest. The dynamic equilibrium between defect formation and defect annihilation during HPT results in a steady state when the lattice parameter of the alloy, the grain size, the microhardness, and other properties of the material remain constant and no longer change with increasing number of anvil revolutions. We simulate the processes of the formation and decomposition of supersaturated solid solution in this work. We have evolved a model to describe the behavior of copper–cobalt alloys during HPT. This model explains well the appearance of the steady state upon HPT and also satisfactorily predicts the temperature, $\sim 750^\circ\text{C}$, at which the cobalt solubility in copper equals the steady state concentration in solid solution upon HPT.

Keywords: high pressure torsion, phase transformation, phenomenological Landau theory

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INTRODUCTION

Severe plastic deformation (SPD), also called megaplastic deformation, can entail interesting phase transformations [1–3]. An important feature of SPD processes is that a sample under deformation conditions cannot be destroyed. The word “deformation” itself acquires a paradoxical meaning, because the shape of a sample does not change during SPD. High pressure torsion (HPT) is one of the most prominent examples of SPD. A flat sample during SPD is enclosed between two rotating piston plungers under high pressure [4]. The HPT process can proceed almost endlessly, i.e., until the plungers are destroyed themselves. However, defect accumulation under SPD cannot continue endless. Simultaneously with defect formation, defects start to relax or annihilate. A steady state occurs when the rate of defect generation is equal to the rate of defect annihilation [5]. This is especially pronounced upon HPT when the processes of dissolution of second-phase particles and their precipitation from the solid solution in the volume are in competition with each other. In particular, this competition and the HPT-induced formation of a steady state have been experimentally studied in Cu–Ag, Cu–Sn, Cu–Co, and Cu–Ni systems [6–8]. A steady state was theoretically considered using Landau phe-

nomenological theory [9, 10]. The critical temperature at which the solubility of the second component in the matrix is equal to its concentration in the solid solution upon HPT has been confirmed in these studies. Above this temperature, HPT causes solid solution decomposition and the formation of new precipitates or the growth of old precipitates, while below this temperature HPT causes the dissolution of particles and the enrichment of the solid solution. It is this temperature that corresponds to the steady state of the system. In fact, the state of a two-component system after annealing can be taken as the initial condition for the beginning of HPT. These works also theoretically considered the change in the initial region of the phase diagrams where silver and tin dissolved in copper during HPT. The limit solubility curve is shown to shift and the steady state is reached. Good agreement between theoretical and experimental data confirms the applicability of Landau theory in the consideration of the processes' taking place. We should note that spiral states are widespread. For instance, there are long-period structures in magnetic materials and in excitable media (heart muscle, etc.) [11] and they are studied using Landau phenomenological theory [11]. However, the limiting behavior of the order parameter was not considered in [9, 10]. This work uses Landau

High Pressure Phase Transformations

Daniel Errandonea



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studies of phase transitions in several ordered vacancy compounds reveal that the existence of ordered vacancies alter the cation anion bond distances and their compressibilities The book is written for students Ph D students and specialists in materials science phase transitions and new materials

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