

Preface

Hydrogen embrittlement or degradation of mechanical properties by hydrogen is a latent problem for structural materials. The problem is serious particularly for high-strength steels, and its importance is increasing with recent needs for hydrogen energy equipment.

Hydrogen embrittlement has been studied for many decades, but its nature is still an unsettled issue. Two reasons are most likely: one is its interdisciplinary attribute covering electrochemistry, materials science, and mechanics, making comprehensive understanding difficult. The other is experimental difficulty in detecting hydrogen behaviors directly. Hydrogen, the lightest element on the periodic table, is mobile and insensitive to external excitations. Coupled with normally very low concentrations of hydrogen, information on its states in materials is limited and most notions must remain speculative about the function of hydrogen. However, recent remarkable advances in experimental techniques in analyses of hydrogen states and of microstructures of materials are unveiling the entity of embrittlement and stimulating new aspects on the mechanism of hydrogen embrittlement. Now is the time to put in order diverse results and notions on hydrogen embrittlement and to prepare the direction to establish principles for materials design and usage against hydrogen problems.

This book provides students and researchers engaging in hydrogen problems with a comprehensive view on hydrogen embrittlement, reviewing previous studies and taking in recent advances. Hydrogen effects must be considered along operating principles in each field, and basic rather than phenomenological stances are adopted in referring to the literature. Emphases are put on experimental facts, but their meanings rather than phenomenological appearance are paid particular attention. Experimental facts are noticed on adopted conditions since the operating mechanism of hydrogen might differ by materials and environments. For theories, assumptions and premises employed are given attention so as to examine their versatility.

Consecutive rather than fragmental setup of contents is attempted so as to facilitate readers' systematic understanding of the problem. The interdisciplinary attribute of the subject requires an understanding of elementary concepts in the

wider field. The task demands textbooks for each field, but brief descriptions of fundamental ideas are presented when necessary.

This book consists of roughly two parts. The first part, from Chaps. 1, 2, 3, 4, and 5, covers basic behaviors of hydrogen in materials after the entry into materials, and the second part, from Chaps. 6, 7, 8, 9, and 10, deals with characteristics of the degradation of mechanical properties and fracture caused by hydrogen.

I am pleased to acknowledge my colleagues, particularly my former students at Waseda University, many of whom are coauthors of my works. I also appreciate works by Prof. K. Takai of Sophia University in devising ingenious methods to clarify the function of hydrogen in embrittlement.

A book of the same title in Japanese was published by Uchida Rokakuho Publishing, Tokyo, Japan, in 2008. The present book fully revised and reorganized the former one, removing some of its contents and adding recent advances. I would like to acknowledge the courtesy of Uchida Rokakuho for permitting the publication of this new book in the present form.

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