Introduction

In the last several years the characterization of materials by metallographic techniques has been paralleled by a remarkable improvement in material capabilities. The ability to measure and characterize those material parameters that provide improved mechanical and physical properties has led directly to the development of new and better materials. Well known metallographic techniques such as hot-stage microscopy, transmission electron microscopy (TEM), and X-ray analysis, as well as the more recent techniques of scanning electron microscopy (SEM) and automatic quantitative metallography have provided the means to measure, characterize, statistically interpret, and, finally, predict the properties of materials.

The successful correlation of the structure and properties of materials, whether on a theoretical or empirical level, has been one of the primary forces in the current materials revolution. Accordingly, the objective of this symposium was to present both review and original papers that demonstrated, on a practical level, the application of an expanded range of metallographic techniques to the measurement, characterization, statistical interpretation, and prediction of the behavior of materials.

The papers presented have been prepared by authorities in their fields and include almost all phases of modern metallographic techniques. The opening session dealt with electron optical metallography covering the areas of electron microprobe analysis, SEM, and high voltage and conventional electron metallography. The second session covered hot-stage microscopy, microhardness techniques, and the new laser techniques of evaluating metallographic structures. The final session included a complete review of the techniques and applications of X-ray metallography and two application papers in the field of superalloys.

This special technical publication includes all the papers presented at the symposium, with the exception of the SEM and microhardness papers, which are not included due to publication deadlines.

Professor Weissman's paper is an excellent and concise summary of the X-ray metallographic techniques that he and his colleagues have developed to a high degree of sophistication over the past several years. In his paper, he describes various applications where combination X-ray methods are used to correlate lattice defects with structure-sensitive properties. In particular, his description of the use of X-ray Pendellösung fringes to analyze the distribu-

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tion of microplastic and elastic strains in crack propagation would be of special interest to researchers working with low dislocation-density materials. In contrast to the more specialized techniques discussed by Weissman, Zwell's paper deals with practical applications of the more common X-ray metallographic techniques such as phase identification, residual-stress analysis, and texture determinations. The author demonstrates the usefulness of these techniques in failure analysis as well as in the development of new alloys.

In their paper, Bramfitt *et al.*, summarize the experimental techniques used in hot-stage light microscopy and the application of these techniques to the study of ferrous transformations. The paper provides a description of all the transformations occurring in low-alloy steels and includes an excellent bibliography. Of particular merit is the authors' work on the austenite to pearlite transformation emphasizing the advantage of *in situ* measurements on a single specimen to determine pearlite-nodule growth rates and transformation kinetics. Another innovative technique in light microscopy is described by Schaefer *et al.* Their paper discusses the basic concepts involved in the analysis of metallographic structures using optical transforms, holography, and other coherent-light methods. For the materials scientists, the most useful applications of holography employ interferometry to study transient events that occur at unpredictable locations, for example, the solidification of transparent analogs of metals.

The following three papers relate to the use of electron optics for characterizing and correlating the structure and properties of materials. In his paper, Professor Goldstein discusses the resolution and types of information that can be obtained from the various X-ray, secondary electron, and backscattered electron signals measured in the electron microprobe. The paper demonstrates the versatility of the microprobe as a metallurgical tool in the characterization of phases, diffusion studies, trace-element analysis, and quantitative metallography. The paper also contains an up-to-date and extensive bibliography. The review paper by Wells and Capenos describes applications of TEM in materials research. In covering selective papers from the literature, the authors provide several practical examples of the role of TEM in the study and understanding of materials system. The scope of applications of electron metallography has been expanded considerably with the advent of high-voltage instruments capable of operating at 1 MeV or more. In the area of high voltage electron metallography, the contributions of Szirmae and Fisher are well known, and their present paper presents a broad review of their work and a look toward the future of high voltage electron metallography (HVEM).

The paper by Muzyka and Maniar demonstrates the application of various metallography methods in optimizing properties of superalloys on the basis of a microstructural approach. The authors illustrate the value of microstructural studies in conjunction with phase relationships in improving hot working, heat-treat response, and the property optimization of iron and iron-nickel base superalloys. The contribution of analytical chemistry in support of microstructure studies is exemplified by Kriege's paper on phase separation as a technique for the characterization of superalloys. Although the paper deals with superalloys, the technique is equally applicable to other material systems.

These introductory comments on the papers contained in this volume illustrate the significant role that metallography plays in the development and characterization of materials. It was our objective in organizing this symposium to show, through both original studies and state-of-the-art reviews, how the metallographic disciplines within the scope of Committee E-4 on Metallography validate the premise that metallography is a practical tool for correlating the structure and properties of materials. We hope that this publication has contributed to the achievement of our objective. The American Society for Testing and Materials (ASTM) and the program chairmen wish to thank the authors for their excellent contributions to the symposium and this volume.

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