

Introduction

The burgeoning in recent years of major new instrumentation and methodology for investigating and analyzing the microstructures of metals and other materials has had many important consequences in the fields of material science and engineering. High-voltage transmission electron microscopy of thin sections, scanning emission or "reflection" electron microscopy of surfaces, and ion and electron microprobe analyzers have opened new channels for obtaining additional information about the internal architecture and constitution of materials on a microscopic scale. Several of the subcommittees of ASTM Committee E-4 have played a pioneering part in these developments. Generally speaking, the ultimate objective in gathering such information is to permit establishment of more basic and quantitative interrelationships between microstructural features and the properties and behavior of materials.

At the same time, rapid progress has been made in discovering basic material parameters that determine the engineering properties of materials and govern their behavior under widely different conditions of test and practical use. One important and timely example, in the field of mechanical behavior of metals, is the establishment and measurement of fracture toughness parameters (critical stress intensity factors or critical flow sizes, or both) for high strength metallic materials, through the application of linear elastic fracture mechanics concepts to the problem of determining the crack growth resistance of materials. Most of this development, from its earliest beginnings, was carried out by the group that now constitutes ASTM Committee E-24 on Fracture Testing of Metals. In addition to the importance of such information for engineering materials evaluation and performance prediction, the availability of such parameters and measurements now is making possible more generalized and basic correlations between mechanical behavior and the microstructural features of materials.

These developments have contributed to the new surge of interest and activity in quantitative stereology and metallography, that has been growing during the past decade. The practice of quantitative metallography, of course, is not new, since measurements of grain size, and of the size and spacing of nonmetallic inclusions and secondary-phase particles, have been made on two-dimensional planes of section for many years, but usually with little or no effect to relate the quantities mea-

sured to the magnitudes of the complete, basic microstructural features, as they exist in three-dimensional space (that is, by application of quantitative stereology). Such measurements have been correlated with property test data or performance characteristics in a rather simple, primitive fashion, with the result that complications, inconsistencies, and exceptions frequently have arisen in the correlations, because the quantities measured were not of fundamental significance or direct pertinence.

Although the groundwork of stereological analysis, involving the theory of curves and surfaces, the mathematics of statistics, geometrical probabilities, and various kinds of geometry, was laid some time ago, unified and comprehensive treatments of the elements of stereological analysis are of relatively recent origin. Furthermore, concise interpretive treatments of this relatively complex subject, which stress physical understanding of the mathematical relationships and provide practical guides to the procedures for estimating three-dimensional features of microstructure, have become available only within the past few years.

Important progress in these fields has set the stage for, and seemingly foretells, an era of intense investigation and determination of the basic interrelationships that exist among the test properties, practical behavior, and three-dimensional microstructural features of materials. Still such effort would be arduous and time consuming, and prohibitively expensive, if the multitude of observations, measurements, and mathematical operations needed, even for a single quantitative characterization of microstructure, had to be carried out by hand methods. Fortunately, revolutionary new instruments and procedures for the automatic gathering, recording, and processing of microstructural information have been fulminating concomitantly. The hardware and software of these machine methods are directly applicable to most types of microscopes (or epidiascope) and microanalyzers, so that it is now practically feasible to conduct many kinds of comprehensive, quantitative, stereological analyses. Also, these methods and equipment are proving extremely useful for making the myriad of more-or-less routine quantitative metallographic measurements (two-dimensional) that are required to provide adequate sampling statistics in process and quality control situations. Considerable activity in this area has been underway for some time in Subcommittee 14 on Quantitative Metallography of ASTM Committee E-4 on Metallography.

In view of this apparently pregnant state of affairs, the time seemed ripe for the organization of a symposium by ASTM to provide a concise, but comprehensive, overview of the field of stereology and quantitative metallography. In planning this one-day symposium, the main thrust of the topics selected, and subject matter solicited, were directed toward current and prospective users of the methodology and equipment, such as metallographers, microscopists, metallurgists, and materials engineers,

who previously had only marginal interest and knowledge of the subject. The ten papers that were presented did appear to serve the intended purpose and audience. Eight of the papers are published in this symposium volume.

The subject matter contained in these papers covers most of the important aspects of quantitative stereology and metallography in sufficient depth to serve as an introduction and brief education for those engaged in the microscopy of materials, as well as for materials engineers and scientists who are interested primarily in application of the methods to research and engineering problems. Thus, it is more than a state-of-the-art review. However, this very much abbreviated treatment of such a broad, complex field cannot be expected to substitute for the classical texts and references on the subject, especially for those interested in advancing the science of stereology.

It is hoped that this publication of the symposium will generate enough interest and curiosity on the part of materials engineers and scientists to encourage new and vigorous efforts to apply the methods of stereology and quantitative metallography to problems involving correlation of microstructural features with the properties and behavior of materials—which is what metallography and the microscopy of materials have been primarily concerned with from the beginning.

G. E. Pellissier

Ernest F. Fullam, Inc.
Scientific Consultants
Schenectady, N. Y.
chairman

S. M. Purdy

Youngstown Sheet & Tube Co.
Youngstown, Ohio
cochairman