Surface Wetting: Characterization, Contact Angle, and Fundamentals

Kock-Yee Law and Hong Zhao

Springer, 2016
162 pages, $99.00 (e-book $69.99)
IBSN 978-3-319-25212-4

Although the authors humbly state in their preface that this book is "not intended for expert researchers, who may view the content as nothing new," I would recommend this book to anyone who thinks they understand (or would like to understand) the complexities in the seemingly simple matter of determining and deciphering wetting of solid surfaces. In their captivating way, the authors provide a very informative view on the state of the field. Through ample reference to key research works—some six to seven decades old or more but largely ignored, and others quite recent—they underscore common misconceptions about surface wetting while providing good insights into the physics behind the phenomenon.

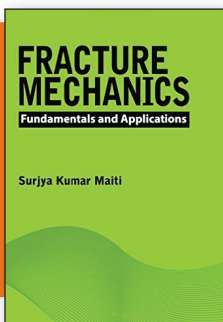The book begins with a short background on the history, importance, and basis for controversy in contact-angle measurements. The next chapter covers proper measurement of contact angles, including critical comparison of common instrumentation and techniques, and advice for best practices. The third chapter discusses Young's equation and what it means, and gets to the heart of why many use it improperly. They argue convincingly that the equation deals with mechanical equilibrium—not thermodynamic equilibrium, as many believe—and then describe the consequences of this formal understanding. In chapter 4, rough surfaces are considered, and some inadequacies of commonly used relations are discussed. Having broken many dogmas in the earlier part of the book, the fifth chapter tries to answer the question of what we actually learn from a contact-angle measurement.

Chapters 6 and 7 give some order to the confusion surrounding concepts of surface energy, surface tension, and Young's angle. In chapter 6, such terms as wettability, adhesion, hydrophilicity/-phobicity, and the related degree of affinity to oils (oleophilicity/-phobicity) are defined clearly and quantitatively. In chapter 7, different approaches to assessing surface tension are provided with emphasis on their shortcomings. The important take-home message is that while surface energy and tension may not be useful concepts in the realm of wetting, the related, practical quantities of wettability and adhesion can be obtained from the readily measured advancing and receding contact angles. The concluding chapter 8 summarizes the key messages of the book, including suggestions for proper experimental practice. Starting with this chapter is a good way to see in a glance what the book has to offer.

The book is well organized and easy to read. Each chapter begins with an abstract and list of keywords. Ample use of figures and tabulated data from the literature, as well as illustrative figures to emphasize certain concepts, enhance the text. Good use is made of cumulative knowledge in the field that has unfortunately been largely ignored. The book is very practical without being merely technical, as well as fundamental while still being accessible.

Reviewer: Sidney R. Cohen of the *Weizmann Institute of Science, Israel.*

Fracture Mechanics: Fundamentals and Applications

Surjya Kumar Maiti

Cambridge University Press, 2015
295 pages, $71.95
ISBN 9781107096769

Fracture mechanics is an essential discipline for predicting the safe operating limits of structures containing flaws such as small interior or surface cracks. It is originally based on the concept of stress amplification at the crack tip, first put forth by A.A. Griffith, with improvements in its underlying scientific basis by others, notably G.R. Irwin.

Maiti's book is an excellent overview textbook on fracture mechanics, with an emphasis on the mechanics perspective and without much emphasis on materials science. As such, it focuses on a mathematical approach to solving for the magnitudes and distributions of stresses in mechanical pieces in a wide variety of geometric configurations. The book is filled with partial differential equations, integral equations, and the occasional Jacobian matrix. There are tables listing the properties of specific metals, but no discussion or comparisons of material properties.

Coverage begins with the simplest case, which assumes the material is brittle, the concentrated stress is localized, and the stress is linearly related to strain. More complex cases are then considered as these assumptions are removed by extending calculations to nonlinear stress–strain, with plastic deformation occurring before the crack length is extended, and the distribution of stress surrounding the crack tip.

The book is divided into nine chapters. The first chapter introduces the topic of fracture mechanics, describes its applications, and sets the scope of the text.
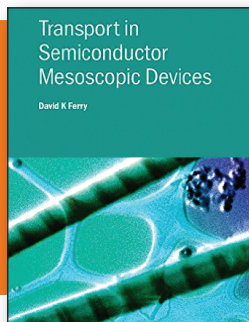
Chapter 2 describes linear elastic-fracture mechanics, its underlying theoretical basis, the stress intensity factor, and the modes that are most frequently considered in the literature (opening, sliding, and shearing modes). The analytical equations delineating the spatial distribution of the normal and shear stress fields surrounding the crack tip are the subject of chapter 3. Chapter 4 treats the impact of the crack opening displacement on the stress. Chapter 5 discusses calculation of the stress intensity factors for different modes and geometries by both analytical expressions and numerical techniques. Chapter 6 covers treatment of cases in which the

applied stress and sample geometry have a combination of modes (i.e., mixed modes). Crack growth rates under fatigue, when the specimen is cyclically subjected to low stresses, are predicted in equations given in chapter 7. Chapter 8 covers elastic-plastic fracture mechanics, which has extended the original scope of fracture mechanics to predict the performance of metals. Chapter 9 describes the experimental methods for measuring the key material properties, such as the plane strain fracture toughness, the crack opening displacement, and the κ-resistance curve.

This book is well designed for a broad survey course on fracture

mechanics. Each chapter contains many worked example problems and a good selection of homework problems with answers. A solution manual is available that includes images that make the major concepts clear, and there are many references to the original sources for more in-depth coverage. This book is a good introduction to fracture mechanics and is suitable for upper-level undergraduates or first-year graduate students.

Reviewer: J.H. Edgar of the Department of Chemical Engineering, Kansas State University, USA.

Transport in Semiconductor Mesoscopic Devices
David K. Ferry

IOP Publishing, 2015
316 pages, $91.72
(Kindle edition with audio/video $137.52)
ISBN 978-0-7503-1102-1

David K. Ferry, from Arizona State University, is an expert in quantum effects, including charge-carrier transport, in semiconductor devices. He is the author/co-author of several well-regarded books and numerous articles in peer-reviewed journals in this area. In this book, Ferry concentrates on elements of transport associated with "mesoscopic devices," which he defines as devices in which "the critical dimensions of the structure are comparable to the corresponding de Broglie wavelength of the electrons." This book was written primarily as a textbook for first-year graduate students on the basis of Ferry's course notes developed over several years.

The material is organized into 10 chapters. The first chapter introduces fundamental concepts in semiconductor physics associated with nanoscale materials and devices, including a short discussion of nanofabrication techniques. The second chapter focuses on wires and channels and uses the quantum point contact as a tool to discuss concepts such as the density of

states, the Landauer transport formalism, scattering matrices, and Green's function approaches. The Aharonov–Bohm effect in mesoscopic structures formed in semiconductor device materials is described in the third chapter. Chapter 4 covers carbon materials, including graphene and carbon nanotubes, as well as topological insulators and chalcogenides. Chapter 5 covers localization and conductance fluctuations and includes a short discussion of disorder and the differences between weak and strong localization, which is based on an approach developed by P.W. Anderson. The chapter concludes with discussions of correlation functions and phase coherence times. Chapter 6 covers three effects in which the conductance is affected by the presence of a magnetic field: the Shubnikov–de Haas effect, the quantum Hall effect, and the fractional quantum Hall effect. The Buttiker–Landauer approach is used to illuminate the latter two effects. Chapter 7 covers spin transport processes, including spin Hall effects, spin injection, spin currents

in nanowires, and spin relaxation. Chapter 8 covers transport processes that involve tunneling effects, including Coulomb blockade, single electron structures, double quantum dot structures, quantum dots and qubits, and resonant tunneling diodes. Chapter 9 covers "open" quantum dots in which "the interior dot region is coupled to the reservoirs by means of waveguide leads." The chapter begins with a discussion of conductance fluctuations from magnetotransport, gate-induced voltage fluctuations, and phase-breaking (coherence) processes. This leads to a discussion of pointer states, pointer state statistics, and hybrid states. Chapter 10 covers hot-carrier effects, including energy loss rates and energy relaxation times.

Each chapter includes dozens of references, which the reader will find very helpful for further studies of the covered topics. This is a very good book that will be suitable for classes of well-prepared, first-year graduate students in this field of study. The book will also be useful to researchers as an introduction to the subject. Finally, the book may also be suitable for advanced undergraduates who have a strong background in quantum mechanics and semiconductor physics.

Reviewer: Steven C. Moss is a senior scientist in the Electronics & Photonics Laboratory at The Aerospace Corporation in Los Angeles, Calif., USA.