

truly represents a fundamental change in the human experience.

Splitting the Second goes on to give a comprehensive review, at a popular level, of the state of modern timekeeping. The author details the cooperation of the national timing laboratories to set an international standard time scale, including descriptions of the clocks used at these laboratories and the means by which the times provided by the clocks are combined to create the basis for all modern civil timekeeping. Jones describes the use of leap seconds, the one-second adjustments to Coordinated Universal Time (UTC), the world's standard time, to reconcile "Physicists' Time" with "Astronomers' Time." He identifies the reconciliation of the two time scales as "the problem with atomic timekeeping" and provides a clear description of this rather confusing issue.

The author's British background has apparently contributed a decidedly British perspective to the story. There is no denying the major contribution of UK scientists to modern timekeeping. British scientists were, in fact, largely responsible for developing the first operational atomic clock. However, contributions to the science of timekeeping from other national laboratories do not receive the attention they have earned.

There are some minor factual problems and some descriptions that might be considered oversimplifications. The global positioning system (GPS), while mentioned, is not properly credited for its importance in the worldwide distribution of accurate time. GPS has now become the dominant means to obtain time, even in ways of which the ultimate user is unaware. Its success and easy availability in providing time even threaten the development of new, more expensive clocks.

The author briefly describes the general concepts of one-way and two-way time transfer. In the former, the user can synchronize a clock using a "broadcast" time signal, without any interaction with the signal provider. In the latter, the user must interact with the provider. Jones details the use of common-view time transfer in the formulation of the Coordinated Universal Time. However, he has left out the use of two-way satellite time transfer, a technique that makes an important contribution to the formation of UTC.

In summary, *Splitting the Second: The Story of Atomic Time* is an interesting, readable account of the state of modern timekeeping. It is not comprehensive and is not the definitive history of this stage of the human

attempt to provide accurate timekeeping. It is, however, a good introduction and well worth reading by those interested in this rather poorly documented area of modern science and technology.

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Silicon Surfaces and Formation of Interfaces: Basic Science in the Industrial World

▶ Jarek Dąbrowski and
Hans-Joachim Müssig
World Scientific, River Edge, N.J.,
2000. \$68.00 (550 pp.)
ISBN 981-02-3286-1

Silicon Surfaces and Formation of Interfaces, by Jarek Dąbrowski and Hans-Joachim Müssig provides a welcome look at the basic sciences of silicon surfaces for the requirements of the fast-paced microelectronic industry. The industry is of enormous importance to communication and information infrastructures. The technology has now reached a level where atomic control of interfaces is a critical requirement for its future generations. Therefore, a wide range of engineers must be aware of the tools and methods that are at their disposal for characterizing and understanding the formation of interfaces, particularly in silicon-based devices. Conversely, surface scientists should learn about technological issues that are likely to benefit from their expertise. The tutorial nature of *Silicon Surfaces and Formation of Interfaces* makes it an insightful resource for both communities.

In the introductory chapter, the authors make a convincing case for the importance of fundamental surface science studies in silicon processing, which, unlike a field like catalysis, thrives on two-dimensional order and atomic perfection at interfaces, making silicon technology fully compatible with surface science techniques.

Dąbrowski and Müssig devote three early chapters to background, including structural and dynamical properties of clean silicon surfaces. This historical description is fascinating, if not concise, and these chapters contain important basic and quantitative information that is nicely summarized in tables and figures. Many readers may skip the details of the controversies that characterized the early days of silicon surface science to focus on the current understanding of clean sur-

faces and the adsorption on and oxidation of silicon surfaces described in the later chapters.

Indeed, the latter part of the book beautifully summarizes the interactions of molecules with the silicon surfaces and thereby makes the important connection to the silicon oxidation and passivation that is so fundamental and critical to the microelectronics industry. It is particularly important and timely for technologists to appreciate the systematic steps taken to characterize and understand the reactions taking place during surface passivation, and to realize that wide gaps in understanding and lively controversies still exist.

In several areas, such as silicon oxide characterization, the authors skillfully provide a concise description of silicon processing technology, highlight the complementary aspects of existing characterization techniques, and incorporate the salient results of scientific investigations. Their discussion of the practical quality issues of the silicon/silicon oxide interface is of great benefit to surface scientists: it provides a concrete motivation for fundamental research. At the end of the book, Dąbrowski and Müssig provide a clear tutorial of materials issues associated with real-life devices, thus enabling and enticing surface scientists to explore these complex issues. The synergy between technology and surface science that is highlighted in this book is a clear reflection of the authors' expertise and the research focus of the Institute for Semiconductor Studies in Frankfurt, Germany, with which they are both associated.

Overall, this book constitutes a solid source of reference material, with over forty tables that conveniently summarize key references in each section. The references do not always reflect all the work done in the field, but they are exhaustive enough (over 1300) that the interested reader can eventually uncover some missing key contributions in the areas discussed.

Within a given chapter, the scope is sometimes uneven. In an attempt to provide in-depth information, the authors occasionally inject much of their own thinking and interpretation of existing work in some areas, while failing to give insight into others. This approach makes it difficult at times to separate educated speculation from established knowledge. Nonetheless, the discussions and opinions presented are welcome and stimulating, and always educational.

For a book of this length and depth, figures are noticeably scarce (only 82).

Yet, the existing figures are uniformly well done with thorough captions, and the authors cleverly illustrate in the text itself the surface structures and adsorption sites, greatly clarifying the presentation. Additionally, the authors raise philosophical questions in the opening and concluding chapters of the book that tend to detract from the real value of this otherwise tutorial volume.

Despite these minor pitfalls, this book is well written and highly educational. I strongly recommend it for materials scientists interested in the properties of silicon as a microelec-

tronic device material, and for micro-mechanical and photonics applications as well.

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