CHEMICAL VAPOR DEPOSITION, 1960-1980

A Bibliography

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FOREWORD

This book will be a welcome desk-top reference for everyone working in the field of chemical vapor deposition (CVD). The steady growth of publications on CVD makes it difficult to find the key references on a new topic without the help of an on-line literature search or a comprehensive, indexed bibliography like this one. In fact, the number of publications on CVD has grown so large, as shown by the size of this bibliography, that in the future it may be necessary to provide separate literature indexes for each major discipline within CVD.

As a glance at this book's table of contents will show, CVD is used to fabricate a wide range of materials. Most of the solid elements and many of the borides, carbides, nitrides, silicides, and chalcogenides have been grown by CVD, as have many III–V and II–VI compounds. Current applications in electronics include optical communications (light sources, optical fibers, and detectors), microwave FETs, solar cells, power transistors, semiconductor memories, and microprocessors. New research on deposition from metalorganic source materials promises to provide improved III–V devices for microwave, high-speed logic, and optoelectronic applications. CVD also provides coatings with special properties, including wear resistance, low friction, heat and corrosion resistance, high hardness, and hermetic sealing. New applications of CVD include two critical problems in energy production: encapsulation of nuclear waste products from fission reactors, and fabrication of "first wall" materials to withstand the extreme conditions of heat and energetic particle bombardment in fusion reactors.

CVD has both contributed to and benefited from the rapid advance of computer technology. For example, microprocessors control most new CVD reactors. Several integrated circuit (IC) manufacturers have gone even further, placing entire CVD epitaxial silicon facilities under computer control. Many of these systems use automated characterization of the product, with feedback to stored programs to control the conditions of deposition. With the development of high-speed central processors, numerical models are possible that may adequately describe the complex transport and chemistry of CVD.

Advances in instrumentation, notably mass spectroscopy and laser Raman spectroscopy, have led to improved *in situ* measurement of gas temperature and composition in CVD reactors. We may hope that measurements and computer modeling will combine to provide an in-depth understanding of actual CVD processes.

The present era of CVD began in the early 1960s, although its beginnings go back to the late 1800s. Early applications of CVD ranged from fabrication of light bulb filaments to deposition of decorative coatings. CVD became widely known only after 1960, largely through its application to the new field of IC manufacture. Polycrystalline silicon ingots, from which all single crystal silicon boules are fabricated, are formed by chemical vapor deposition; in fact this process is the largest single application of CVD. Growth of epitaxial silicon layers onto single crystal substrates is funda-

mental to processing of bipolar and many other kinds of ICs. Other CVD thin films that are essential to IC fabrication include polycrystalline silicon, silicon dioxide, and silicon nitride. A multimillion dollar industry has grown up to supply the deposition equipment for these processes.

Several examples from the literature illustrate stages in the growth of CVD technology. The first book on the subject of CVD, by C. F. Powell, I. E. Campbell, and B. W. Gonser, was published in 1955. The title of the book, *Vapor Plating,* reflected the major application of CVD at the time. The rapid advances in theory and applications in the early 1960s led to the publication in 1966 of *Vapor Deposition,* a complete revision of *Vapor Plating,* under the editorship of C. F. Powell, J. H. Oxley, and J. M. Blocher, Jr. The First International Conference on Crystal Growth was held the same year, and the Conference on Chemical Vapor Deposition of Refractory Metals, Alloys, and Compounds (effectively the First International Conference on Chemical Vapor Deposition) was held the following year, in 1967. This was followed by the First International Conference on Vapour Growth and Epitaxy in 1970. As Figure 1 in the Introduction to this book shows, there was a veritable explosion of publications in the mid-1960s. The changes in the number of publications per year in the 1970s mirror the economic fortunes of the decade, but the overall trend is still toward growth in the rate of publication, with about 500 new papers appearing each year at present.

A list of 1981 conferences shows the continuing vitality of CVD technology. The meetings include the First International Conference on Metalorganic Vapor Phase Epitaxy for Semiconductors, the Fifth American Conference on Crystal Growth, the Fifth International Conference on Vapour Growth and Epitaxy, and the Eighth International Conference on Chemical Vapor Deposition.

Clearly, the value and importance of CVD is continuing to grow. This comprehensive, indexed bibliography provides a welcome and important service to everyone working in the field.

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INTRODUCTION

Introduction

This is a comprehensive bibliography of 5362 references on chemical vapor deposition (CVD) and vapor transport processes. The emphasis is on methods, reactions, epitaxy, thin film deposition, and crystal growth by CVD or transport reactions. Although some references on *properties* of CVD-grown materials are included, coverage is not comprehensive.

CVD is an old technique for the preparation and purification of materials. It began as early as the late 1800s. Later, it was used to deposit carbides and other protective coatings on metals. In the early 1960s, vapor deposition of silicon became widespread. As the microelectronics industry grew, CVD played an increasingly useful role in the preparation of the high-purity materials needed, and today, it is used to deposit not only metals, but also oxides, semiconductor materials, and refractories. Two of the most recent developments in CVD are its application to optical fiber production and deposition using organometallic compounds.

Figure 1 shows the number of publications per year in this bibliography. There was a large discontinuity in 1967, followed by slower growth through the 1970s. In the last four years, an average of 460 publications on CVD appeared. The large increase in 1967 to 1969 is probably due to the inauguration of international conferences on crystal growth (in 1967) and CVD (in 1968).

Organization

This bibliography is organized into 17 sections, as shown in the table of contents. References pertinent to more than one section are listed in the lowest-numbered section to which they apply; no cross references were generated. For statistical interest, the number of references in each section is listed in the table of contents. In each section, the title, authors, and source are listed for each reference. When available, the abstract number from *Chemical Abstracts* (CA), *Science Abstracts A* (SAA), or *Science Abstracts B* (SAB) is listed on the last line of the entry. Within each section, entries are listed alphabetically by author.

Permuted title (Key Word in Context) and author indexes follow the bibliographic listing. The permuted title index is particularly useful as a subject guide to the bibliography and provides many additional entry points besides the section groupings. The terms CHEMICAL, VAPOR, and DEPOSITION are not indexed. Terms prefixed by common prefixes such as DI..., TRI..., etc., are indexed under the root term. Parenthetical notes were appended to many of the titles in order to enrich the permuted title index.

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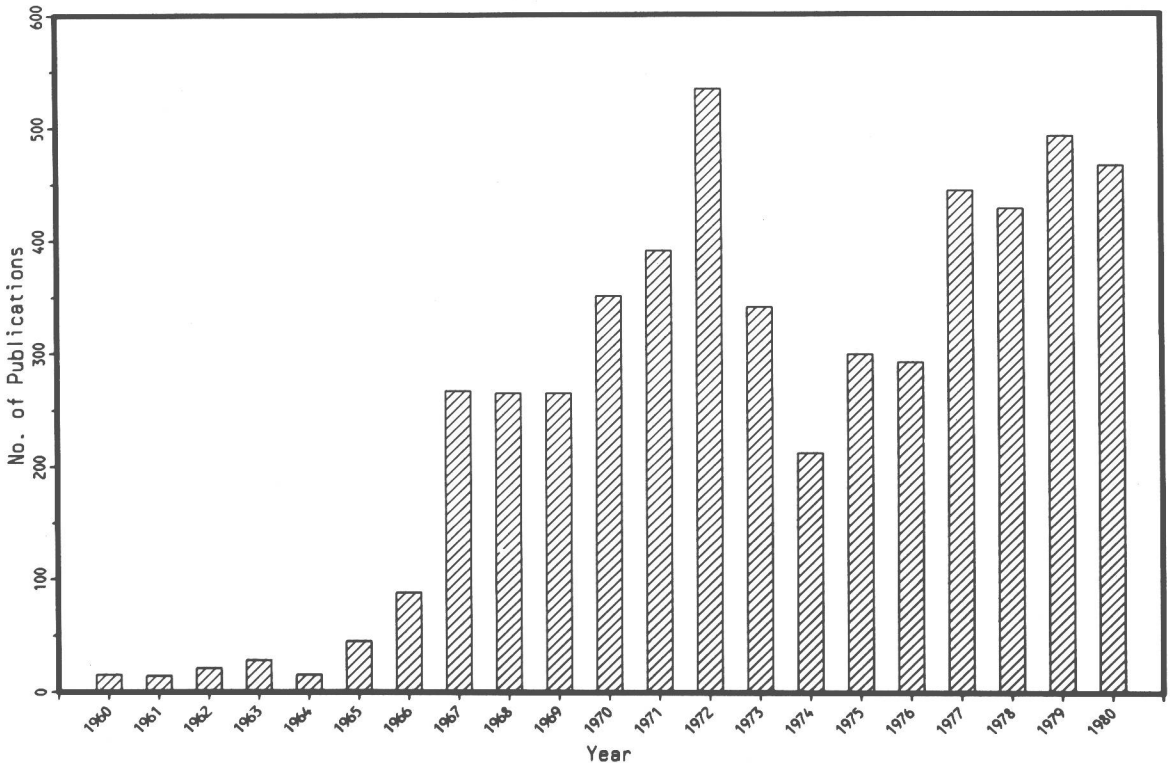

Figure 1. CVD publications per year.

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DONALD T. HAWKINS

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