

## Review Paper

# Filament-activated Chemical Vapour Deposition of Nitride Thin Films

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We have applied the novel method of hot filament-activated chemical vapour deposition (HFCVD) for low-temperature deposition of a variety of nitride thin films. In this paper the results from our recent work on aluminium, silicon and titanium nitride have been reviewed. In the HFCVD method a hot tungsten filament (1500–1850°C) was utilised to decompose ammonia in order to deposit nitride films at low substrate temperatures and high rates. The substrate temperatures ranged from 245 to 600°C. The film properties were characterised by a number of analytical and optical methods. The effect of various deposition conditions on film properties was studied. All the films obtained were of high chemical purity and had very low or no detectable tungsten contamination from the filament metal.

**KEYWORDS:** hot filament chemical vapour deposition; CVD; high-rate deposition; ammonia; silicon nitride; aluminium nitride; titanium nitride

## INTRODUCTION

Hot filament-activated chemical vapour deposition (HFCVD) is a simple and a relatively inexpensive method that has been used to deposit a variety of materials. In this method a resistively heated filament (tungsten, rhenium or tantalum) is used to thermally and/or catalytically dissociate one or more of the source gas molecules to produce reactive precursors needed to form the desired film. One of the most attractive features of the HFCVD approach is that the thermal activation of reactants is decoupled from the film growth step at the substrate. This simple approach allows for deposition at low substrate temperatures (from room temperature to 400°C). High film deposition rates can be obtained by appropriately adjusting the deposition conditions. Using proper reactor

design and operating regimes, films with varied properties can be deposited with little or no contamination from reactions at the reactor walls as is found in other techniques such as plasma-assisted chemical vapour deposition.

HFCVD has been extensively used for over a decade to deposit polycrystalline diamond thin films.<sup>1–3</sup> Polycrystalline diamond has been deposited on a number of different non-diamond substrates using a variety of carbon-containing gases and under varying conditions in a hot filament system. However, typical conditions under which good quality, highly faceted diamond is obtained are: filament temperature, 2000–2200°C; filament-to-substrate distance, 1.0 cm; substrate temperature, 800–1000°C; reactor pressure, 20–30 Torr; gas composition, 0.5% CH<sub>4</sub> in hydrogen. This simple technique has provided great insight into the process chemistry and the mechanism of diamond

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# Thin Films By Chemical Vapour Deposition Thin Films Science And Technology Vol 7

**Reza Fazel-Rezai**



## **Thin Films By Chemical Vapour Deposition Thin Films Science And Technology Vol 7:**

**Handbook of Surfaces and Interfaces of Materials, Five-Volume Set** Hari Singh Nalwa, 2001-10-26 This handbook brings together under a single cover all aspects of the chemistry physics and engineering of surfaces and interfaces of materials currently studied in academic and industrial research It covers different experimental and theoretical aspects of surfaces and interfaces their physical properties and spectroscopic techniques that have been applied to a wide class of inorganic organic polymer and biological materials The diversified technological areas of surface science reflect the explosion of scientific information on surfaces and interfaces of materials and their spectroscopic characterization The large volume of experimental data on chemistry physics and engineering aspects of materials surfaces and interfaces remains scattered in so many different periodicals therefore this handbook compilation is needed The information presented in this multivolume reference draws on two decades of pioneering research on the surfaces and interfaces of materials to offer a complete perspective on the topic These five volumes Surface and Interface Phenomena Surface Characterization and Properties Nanostructures Micelles and Colloids Thin Films and Layers Biointerfaces and Applications provide multidisciplinary review chapters and summarize the current status of the field covering important scientific and technological developments made over past decades in surfaces and interfaces of materials and spectroscopic techniques with contributions from internationally recognized experts from all over the world Fully cross referenced this book has clear precise and wide appeal as an essential reference source long due for the scientific community The complete reference on the topic of surfaces and interfaces of materials The information presented in this multivolume reference draws on two decades of pioneering research Provides multidisciplinary review chapters and summarizes the current status of the field Covers important scientific and technological developments made over past decades in surfaces and interfaces of materials and spectroscopic techniques Contributions from internationally recognized experts from all over the world **Tin Chemistry** Marcel Gielen, 2008-09-15 Tin chemistry retains a place in contemporary science as an important element owing to its wide range of applications New and exciting research is being generated on an annual basis from all parts of the world the study of tin and its compounds attracts considerable interest from a range of perspectives such as organic synthesis medicine materials chemistry catalysis and environment Tin Chemistry Fundamentals Frontiers and Applications collects in one comprehensive volume authoritative and concise snapshots of modern tin chemistry in a full range of applications Over forty of the leading tin chemistry experts have contributed reviews in six themes fundamentals in tin chemistry materials chemistry and structural chemistry of tin compounds medicinal and biocidal applications of tin compounds tin in the environment tin in organic synthesis tin in catalysis Tin Chemistry Fundamentals Frontiers and Applications is an essential overview of modern perspectives on this important element for the specialist and non specialist alike It will promote cross disciplinary interactions and at the same time be an essential teaching resource for advanced university classes *Thin*

*Films by Chemical Vapour Deposition* C.E. Morosanu, 2016-06-22 The explosive growth in the semiconductor industry has caused a rapid evolution of thin film materials that lend themselves to the fabrication of state of the art semiconductor devices Early in the 1960s an old research technique named chemical vapour phase deposition CVD which has several unique advantages developed into the most widely used technique for thin film preparation in electronics technology In the last 25 years tremendous advances have been made in the science and technology of thin films prepared by means of CVD This book presents in a single volume an up to date overview of the important field of CVD processes which has never been completely reviewed previously Contents Part I 1 Evolution of CVD Films Introductory remarks Short history of CVD thin films II Fundamentals 2 Techniques of Preparing Thin Films Electrolytic deposition techniques Vacuum deposition techniques Plasma deposition techniques Liquid phase deposition techniques Solid phase deposition techniques Chemical vapour conversion of substrate Chemical vapour deposition Comparison between CVD and other thin film deposition techniques 3 Chemical Processes Used in CVD Introduction Description of chemical reactions used in CVD 4 Thermodynamics of CVD Feasibility of a CVD process Techniques for equilibrium calculations in CVD systems Examples of thermodynamic studies of CVD systems 5 Kinetics of CVD Steps and control type of a CVD heterogeneous reaction Influence of experimental parameters on thin film deposition rate Continuous measurement of the deposition rate Experimental methods for studying CVD kinetics Role of homogeneous reactions in CVD Mechanism of CVD processes Kinetics and mechanism of dopant incorporation Transport phenomena in CVD Status of kinetic and mechanism investigations in CVD systems 6 Measurement of Thin Film Thickness Mechanical methods Mechanical optical methods Optical methods Electrical methods Miscellaneous methods 7 Nucleation and Growth of CVD Films Stages in the nucleation and growth mechanism Regimes of nucleation and growth Nucleation theory Dependence of nucleation on deposition parameters Heterogeneous nucleation and CVD film structural forms Homogeneous nucleation Experimental techniques Experimental results of CVD film nucleation 8 Thin Film Structure Techniques for studying thin film structure Structural defects in CVD thin films 9 Analysis of CVD Films Analysis techniques of thin film bulk Analysis techniques of thin film surfaces Film composition measurement Depth concentration profiling 10 Properties of CVD Films Mechanical properties Thermal properties Optical properties Photoelectric properties Electrical properties Magnetic properties Chemical properties Part III 11 Equipment and Substrates Equipment for CVD Safety in CVD Substrates 12 Preparation and Properties of Semiconducting Thin Films Homoepitaxial semiconducting films Heteroepitaxial semiconducting films 13 Preparation and Properties of Amorphous Insulating Thin Films Oxides Nitrides and Oxynitrides Polymeric thin films 14 Preparation and Properties of Conductive Thin Films Metals and metal alloys Resistor materials Transparent conducting films Miscellaneous materials 15 Preparation and Properties of Superconducting and Magnetic Thin Films Superconducting materials Magnetic materials 16 Uses of CVD Thin Films Applications in electronics and microelectronics Applications in the field of microwaves and optoelectronics Miscellaneous applications Artificial

heterostructures Quantum wells superlattices monolayers two dimensional electron gases Part V 17 Present and Future Importance of CVD Films      **Kirk-Othmer Encyclopedia of Chemical Technology, Volume 23** Kirk-Othmer,2006-11-10 The fifth edition of the Kirk Othmer Encyclopedia of Chemical Technology builds upon the solid foundation of the previous editions which have proven to be a mainstay for chemists biochemists and engineers at academic industrial and government institutions since publication of the first edition in 1949 The new edition includes necessary adjustments and modernization of the content to reflect changes and developments in chemical technology      **Solid State Science and Technology IV** Nay Ming Huang,Saadah Abd Rahman,Kai Lin Woon,2014-02-13 Selected peer reviewed papers from the 4th International Conference on Solid State Science and Technology ICSSST 2012 December 18 20 2012 Melaka Malaysia      **Surface Engineering Series Volume 2: Chemical Vapor Deposition** Edited by Jong-Hee Park and T.S. Sudarshan,2000-05-01 This handbook provides guidelines and practical information on the chemical vapor deposition CVD process for surface engineering design product development and manufacturing The first of the 14 chapters discuss the basic principles of CVD thermodynamics and kinetics stresses and mechanical sta      **Biomedical Engineering** Reza Fazel-Rezai,2011-08-29 In all different areas in biomedical engineering the ultimate objectives in research and education are to improve the quality life reduce the impact of disease on the everyday life of individuals and provide an appropriate infrastructure to promote and enhance the interaction of biomedical engineering researchers This book is prepared in two volumes to introduce a recent advances in different areas of biomedical engineering such as biomaterials cellular engineering biomedical devices nanotechnology and biomechanics It is hoped that both of the volumes will bring more awareness about the biomedical engineering field and help in completing or establishing new research areas in biomedical engineering      *Handbook of Surfaces and Interfaces of Materials: Solid thin films and layers* Hari Singh Nalwa,2001      **Silicon Carbide** Moumita Mukherjee,2011-10-10 Silicon Carbide SiC and its polytypes used primarily for grinding and high temperature ceramics have been a part of human civilization for a long time The inherent ability of SiC devices to operate with higher efficiency and lower environmental footprint than silicon based devices at high temperatures and under high voltages pushes SiC on the verge of becoming the material of choice for high power electronics and optoelectronics What is more important SiC is emerging to become a template for graphene fabrication and a material for the next generation of sub 32nm semiconductor devices It is thus increasingly clear that SiC electronic systems will dominate the new energy and transport technologies of the 21st century In 21 chapters of the book special emphasis has been placed on the materials aspects and developments thereof To that end about 70% of the book addresses the theory crystal growth defects surface and interface properties characterization and processing issues pertaining to SiC The remaining 30% of the book covers the electronic device aspects of this material Overall this book will be valuable as a reference for SiC researchers for a few years to come This book prestigiously covers our current understanding of SiC as a semiconductor material in electronics The primary target for the

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