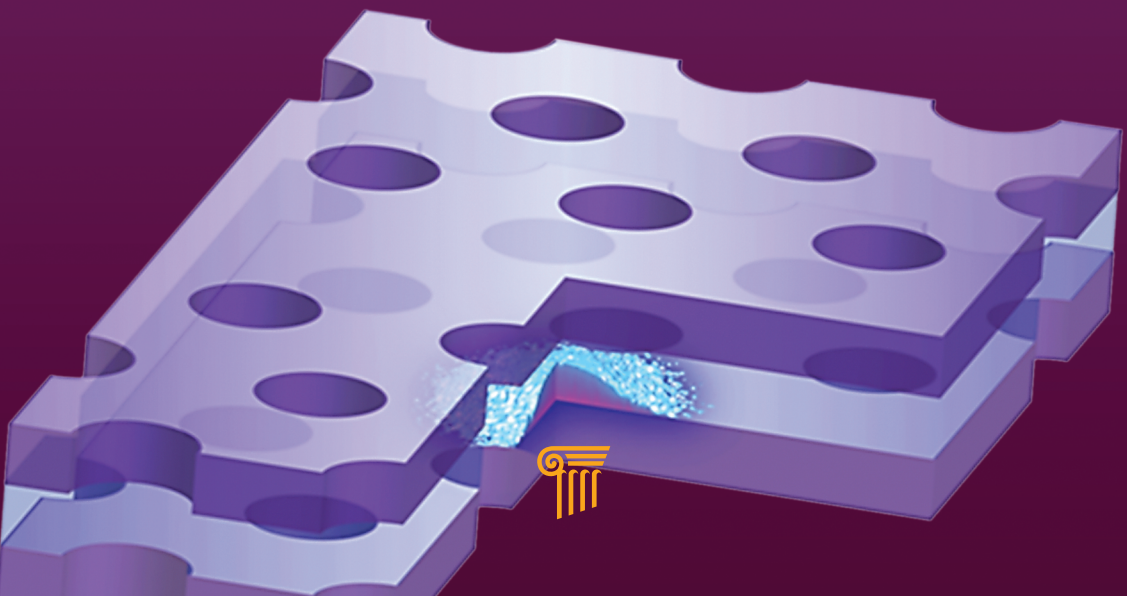


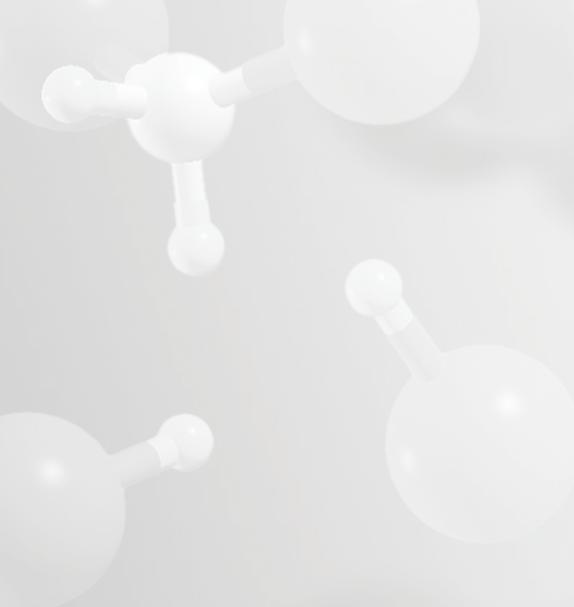


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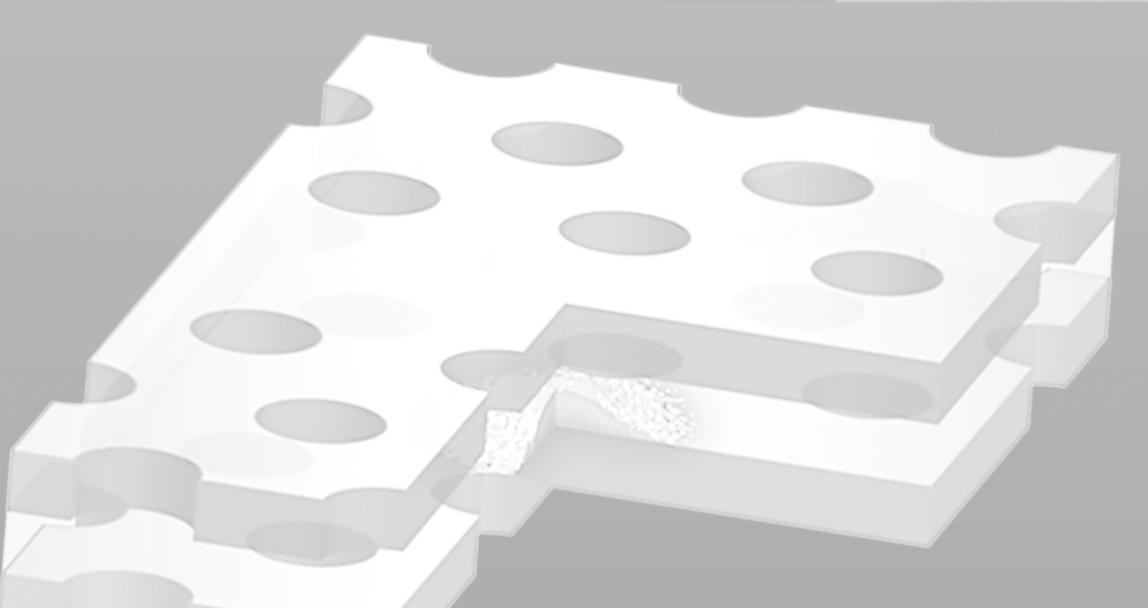
Hydrogenated Dilute Nitride Semiconductors

Theory, Properties, and Applications





**Hydrogenated
Dilute Nitride
Semiconductors**



The image features a 3D schematic of a semiconductor device. It shows a layered structure with a top layer containing a grid of circular features, possibly representing a quantum dot array or a patterned surface. Below this is a thicker layer, and at the bottom is a substrate. A small, textured region is highlighted on the interface between the middle and bottom layers, indicating a specific material or defect. The entire image is rendered in grayscale.

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Preface

Dilute nitride semiconductors are an example of the failure of “linear” models for the physical properties of solids: the addition of a few percent of N to GaAs causes changes in the physical properties that are opposite to those expected, assuming a linear interpolation of the GaAs and GaN properties. Even more surprisingly, the effect of nitrogen incorporation can be eliminated by exposure of the sample to a hydrogen flow. This book addresses in detail the modifications of the electronic structure and optical and structural properties induced by atomic hydrogen irradiation in technologically relevant dilute nitride semiconductors. The discussion of the experimental results from several techniques is enriched by state-of-the-art theoretical studies aimed at clarifying the origin of hydrogenation effects, which resides in the formation of specific nitrogen–hydrogen complexes. The nonlinear behavior of nitrogen and the passivation effect of hydrogen in dilute nitrides open the way to the manufacture of a new class of nanostructures with in-plane variation of the optical band gap.

The idea of this book emerged as an extension of an invited talk I gave in 2011 at the International Conference on Materials for Advanced Technologies (ICMAT 2011) in Singapore. The early outline of a monograph on the structural effects of hydrogenation was expanded in order to cover all aspects related to hydrogenated dilute nitride semiconductors, depending on the consideration that none of the books available on the topic of dilute nitrides had focused on the effects of hydrogenation. We estimated, indeed, that the huge number of recent published results on the theory, characterization, and nanomanipulation of hydrogenated dilute nitrides deserved collection in the form of a free-standing review volume.

With the present book, which is born out of several exchanges and collaborations between the different authors, we intend to tell

the complete story of the amazing effects of hydrogen irradiation, from their first observation to the discovery of their physical origin and potential technology transfer. Our work primarily aims to guide graduate students and young scientists into the field but should be also of interest for more experienced scientists in research laboratories and academia. Moreover, we believe that the wide range and complementarity of the experimental techniques applied in the research here presented could inspire similar approaches in other fields of semiconductor science and condensed matter.

The book begins with an introductory chapter giving an overview of the unusual electronic structure and properties of dilute nitrides. This is followed by two chapters that present the hydrogenation technique and its effects on electronic properties and defects. The fourth chapter provides the theoretical basis of the mechanism of H-induced N passivation in dilute nitrides. This is followed by three chapters devoted to the effects of hydrogenation on the structure, addressed by different characterization techniques that allowed us to unveil the detailed structure of the specific N–H defect ruling the physical properties of these alloys. The last chapter describes how spatially selective hydrogenation of dilute nitride semiconductors can be used for the fabrication of a new class of site-controlled micro- and nanostructures with technological applications in nanophotonics and nanoelectronics.

It is a pleasure to acknowledge all the authors for the substantial time and efforts dedicated to the preparation of the different chapters. I appreciated very much their care and motivation toward a topic for which we share the same passion and enthusiasm. I would like to express many thanks to Stanford Chong for the invitation to develop the concepts of my talk into a book and to all Pan Stanford Publishing staff, in particular to Sarabjeet Garcha, Ritesh Kumar, and Archana Ziradkar, for their invaluable help while preparing the manuscript.

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