Preface

Most inorganic materials can be rendered noncrystalline by vapor condensation onto cooled substrates, but only a select few can be cooled from the molten state to yield a bulk glass that displays a softening at the glass transition temperature (T_g). A glass is formed by cooling (or supercooling) a melt and is widely regarded as a frozen solution.

The origin of the glass forming tendency has been the subject of discussions and debate in the scientific community for over 60 years. In recent years, the development and maturing of new ideas based on interatomic forces acting as mechanical constraints, the advent of new experimental probes of glass structure and dynamics, and large scale molecular dynamic simulations of covalently bonded networks, is providing, new insights into the morphological structure of network glasses. In Condensed Matter Science, we are used to the notion that atomic scale structure forms the starting point to determine the physical behavior of crystalline solids. One expects that in glassy solids as well, the atomic scale structure will be intimately tied to the physical behavior of glasses, including the glass forming tendency. And while there are important kinetic effects that control the glass formation process, these effects are not decoupled from the structural organization of matter as atomic motion is arrested at T_g. The nature of the glass transition continues to be a subject of profound discussions in basis science.

The scope of this volume is on insulating and semiconducting glasses focussing on inorganic materials that encompass a variety of optical and electronic materials. Glasses based on metallic systems and organic polymers are not covered in this volume, although several reviews on these materials have appeared in the literature.

The book is fortunate to have *Austen Angell* (Chapter 1) and *James Phillips* (Chapter 2) introducing ideas on the nature of the glass transition with the former providing an overview, and the latter commenting specifically on molecular glasses. A more traditional view of glass phenomenology is provided by *Ivan Gutzow* in Chapter 3. Interatomic forces serve as mechanical constraints and play a central role in determining the mechanical and chemical behavior of glassy networks. When a network structure becomes barely rigid, the glass forming tendency is apparently also optimized. In Chapter 4, *Michael Thorpe* reviews ideas on the onset of rigidity in atypical and generic networks. In the real world, structure of glasses are probed by elastic scattering methods [Chapter 5(A)] as reviewed by *Adrian Wright* and by an array of chemically specific nuclear resonance methods that have proved to be rather powerful in decoding local structures. These include the Mössbauer effect reviewed by *Punit Boolchand* [Chapter 5(B)], Nuclear Quadrupole resonance reviewed by *Phillip Bray* [Chapter 5(C)], and Solid State Nuclear Magnetic resonance reviewed by *Hellmut Eckert* [Chapter 5(D)]. New insights into atomic and molecular dynamics in glasses have emerged from an impressive array of vibrational spectroscopies; including inelastic neutron scattering as reviewed by *Ron Cappelletti* [Chapter 6(A)], Lamb-Mössbauer factors as a probe of low frequency vibrational excitations as reviewed by *Punit Boolchand* [Chapter 6(B)], Raman scattering as reviewed by *Kazuo Murase* [Chapter 6(C)] and very low frequency acoustic excitations probed by Brillouin scattering as reviewed by *Claire Levelut* [Chapter 6(D)].

In the early sixties, one discovered that an excess of very low frequency vibrational excitations over Debye-like ones represents a generic feature of the glassy state of matter. Thirty years later these excitations continue to be identified with tunneling states although their microscopic origin continues to pose a challenge. Model systems for such tunneling states are identified in crystalline solids as well. The subject is reviewed by *Siegfried Hunklinger* and *Christian Enss* in Chapter 7. The physics of electrical transport in disordered semiconductors is reviewed by *Harold Overhof and Peter Thomas* in Chapter 8.

Since the early 1990's, the rapid growth of computing power accessible even on small machines, and the development of efficient computing algorithms has made feasible molecular dynamic simulations of covalently bonded random networks, as elegantly illustrated by *David Drabold* in Chapter 9. He develops the interaction from first principles and is able to handle ensembles of typically hundreds of atoms.

Hellmut Fritzsche reviews light induced effects in chalcogenide glasses (Chapter 10), addressing both the scalar and vector effects, an area in which our understanding of the mechanistic details is currently evolving. Chalcohalide glasses, based on alloys of the chalcogens (S, Se and Te) and halogens (Cl, Br and I) with the tathogens (C, Si, Ge, Sn) and the pnictides (P, As, Sb), have gained popularity as low loss infrared optical fiber materials. *Jacques Lucas* has reviewed the subject in Chapter 11.

The economic well-being of a field of scientific endeavor is ultimately tied to the evolution of commercial products. Glass science has been particularly fertile in this regard as illustrated in the last chapter of the book. Apart from xerography and silica fibers, one of the other large applications of glasses resides in rewrittable optical memory discs, now in use in several large sized personal computers, as discussed by *Stan Ovshinsky* in Chapter 12(A). Amorphous semiconductors have also found applications in X-ray imaging with important medical benefits as illustrated by *Safa Kasap* and *John Rowland* in Chapter 12(B). Light induced effects in glasses have also served as the base for digital and holographic storage of information, and its reading in real time as reviewed by *Maria Mitkova* in Chapter 12(C). The antiquated cathode ray tube as a display device may be replaced by several new emerging technologies. One such, based on diamond-like carbon films, utilizes their negative electron affinity, and are finding use as active elements in flat-panel displays as reviewed by *James Jaskie* in the final Chapter 12(D) of the book.

I hope the book will be useful to entry level graduate students, and also to established researchers, interested in glass science and applications of these fascinating materials, in a variety of disciplines in the physical sciences (physics, chemistry and geology) and engineering (materials science and engineering, electrical engineering).

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