Preface

The discovery in the mid-1950s by N. A. Goryunova and B. T. Kolomiets at A. F. Ioffe Physico-Technical Institute in Leningrad of the semiconducting properties of amorphous chalcogenide alloys opened up a new field in solid state physics, namely, amorphous semiconductors. The existence of semiconducting properties, i.e. of the forbidden energy gap in the density of states of disordered materials was very puzzling since the band structure of solids had been usually derived from the long-range order, or the periodic nature of the crystalline phase. Another important class of amorphous semiconductors includes hydrogenated amorphous silicon and related tetrahedrally bonded materials. While chalcogenide glasses typically possess *p*-type conductivity and cannot be doped, hydrogenated amorphous silicon can be doped which opened up completely new perspectives of the creation of amorphous semiconductor *devices* attracting further interest to this new field of research.

Possessing the typical properties of their crystalline counterparts, amorphous semiconductors additionally have characteristics unique to the amorphous phase. Intrinsically metastable, they can undergo transformations between different structural states with concomitant property changes. Such changes are known for both chalcogenide glasses and tetrahedrally bonded amorphous semiconductors. A special class of materials, the so-called phase-change materials exhibit a reversible transition between the crystalline and amorphous phases with an unusually large optical and electrical property contrast between the two phases. The proposal by S. R. Ovshinsky in the early 1960s to use these materials for memory applications marked the beginning of a vast and extremely fruitful field.

The reader may have never thought about this, but when one takes a laptop computer in one's hands, or watches a high-resolution TV one comes into contact with amorphous silicon: most of the flat panel displays contain thin film transistors that utilise amorphous silicon. Should one save data on a re-writable optical disc, one uses phase-change materials, another class of amorphous chalcogenides without which modern multimedia systems would have been impossible. In recent years phase-change materials have been attracting increasing attention due to their excellent scaling and cycling characteristics which made them the leading candidate to replace the currently ubiquitous FLASH memory. Samsung and Micron Technology Inc. have already started commercial production of phase-change random-access memory chips and Samsung has also started to use the latter in their mobile phones. Not only are amorphous semiconductors suitable for these applications, they are unique materials which ensured that the present computers, TVs, DVDs and quite a few other mobile devices became available to modern society.

The present monograph is devoted to structural metastability in both classes of chalcogenide alloys, i.e. chalcogenide glasses and phase-change alloys. While these two classes of materials are usually considered separately in the published literature, they possess numerous similar features and the authors believe that the inclusion of them under a single cover will close the gap and be enriching.

The structure of this book is as follows. Chapter 1 deals with the fundamentals of amorphous semiconductors whose properties are described in Chap. 2. Since material properties are determined by the structure, the latter is of significant importance and methods to investigate it are described in Chap. 3. Chapters 4–7 are dedicated to photo-induced metastability in chalcogenide glasses. This description starts with reversible photostructural changes (Chap. 4), followed by phenomena induced by polarised light (Chap. 5). Photo-induced crystallisation and amorphisation are the subject of Chap. 6 and phenomena occurring in chalcogenide glass–metal structures are described in Chap. 7. Chapters 8–11 concentrate on phase-change alloys. First, the structure of phase-change alloys in the crystalline (Chap. 8) and amorphous (Chap. 9) phases is described. Chapter 10 reviews pressure-induced transformations in phase-change alloys and this part of the book is concluded by Chap. 11 where atomistic mechanisms of the phase-change process are discussed. Finally, in Chap. 12 we discuss the present and future applications of these materials.

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