

# Topics in Applied Physics Volume 46



# Topics in Applied Physics

Founded by Helmut K. V. Lotsch

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# Glassy Metals I

Ionic Structure, Electronic Transport,  
and Crystallization

Edited by H.-J. Güntherodt and H. Beck

With Contributions by

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W. L. Johnson U. Köster A. P. Malozemoff

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With 119 Figures

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## Preface

The field of glassy metals or metallic glasses has seen enormous development during recent years. For the uninitiated the notion of a "metallic glass" may seem rather unusual, since one would primarily associate "glass" with transparent and insulating window material. However, the term glass is nowadays almost unanimously used for an amorphous substance which is obtained by cooling the corresponding melt. Besides glassy metals there are other types of amorphous metals produced, for instance, by evaporation or sputtering techniques. In contrast to most dielectric glasses, conducting materials have to be quenched very rapidly in order to overcome crystallization in the cooling process. Thus the development of such quenching techniques was the necessary condition for an intensive and systematic investigation of glassy metals. The rapid progress and the broad interest in this field can be seen by the fact that the third international conference on rapidly quenched metals in Brighton, 1978, gathered 235 participants from eighteen nations.

Metallic glasses are new substances with exciting properties which are of interest not only for basic solid-state physics but also for metallurgy, surface chemistry, and technology. For the physicist interested in pure research they offer a unique opportunity to study bulk disordered metallic systems in solid form and to find connections with corresponding facts in the liquid phase. The theoretical description of ionic and electronic structure of amorphous materials is, of course, an outstanding problem which is, far from being adequately solved, in full development at the present time. Moreover metallic glasses have properties which are quite unexpected for solid metals and make them promising candidates also for technical applications. In order to list but a few facts, the following properties can be found in metallic glasses: high mechanical ductility and yield strength, high magnetic permeability, low coercive forces, unusual corrosion resistance, and temperature-independent electrical conductivity. Metallic glasses for magnetic shielding purposes are already on the market and applications for transformer materials and tape recorder heads seem to be underway.

The present volume is the first of two devoted to the physical properties of metallic glasses. Experimentalists and theoreticians active in the field present recent results and actual research problems in this domain of condensed matter physics. After an introduction which is meant to create a general and unifying framework for the various topics, P. Duwez gives a personal historical introduction into the development of the subject of metallic glasses, which

began, about twenty years ago, in his laboratory. The topics covered in this first volume are the following:

- Special methods of structure investigation: EDXD (T. Egami) and EXAFS (J. Wong)
- Special aspects of ionic dynamics, namely low-energy excitations – which have their counterpart in insulating glasses (J. L. Black) – and Brillouin scattering (A. P. Malozemoff)
- A pseudopotential approach to a first principle treatment of structure and stability of simple metallic glasses (J. Hafner)
- Electrical transport properties: normal electrical conductivity (L. V. Meisel and P. J. Cote) and superconductivity (W. L. Johnson)
- An overview of the crystallization processes which occur when metallic glasses are heated up (U. Köster and U. Herold).

The second volume should include the following further topics: structure determination by model building and by X-ray and neutron scattering techniques, defects, mechanical and elastic properties, magnetism electron spectroscopy and the theory of electronic structure, corrosion resistance, and application.

The editors acknowledge stimulating discussions, active help, and valuable cooperation of their collaborators and colleagues working in the field of metallic glasses. Thanks are also due to all of the contributors for keeping the deadlines and for their cooperation.

Basel and Neuchâtel, January 1981

*H.-J. Güntherodt H. Beck*

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