

FOREWORD

Currently, it becomes common to call *cryocrystals* the simplest molecular substances whose melting occurs well below the room temperature. These are the solidifying inert gases (*rare-gas solids*) and the crystalline bodies formed by diatomic (H_2 , N_2 , O_2 , CO , F_2 , *etc.*) or polyatomic (CO_2 , N_2O , NH_3 , CH_4 , *etc.*) molecules. In the molecular cryocrystals different from the rare-gas solids, the lattice interaction pattern depends on not only the intermolecular distance, but also the orientation of the molecules relative one another. It is the strength and kind of the off-center interaction of the molecules that mainly influence the peculiarities of the formation of crystal structure, polymorphism, rotation intensity of the molecules, and thermodynamic or mechanical properties of the crystals.

A crystal lattice of the cryocrystals typically exhibits high symmetry, and the molecular interaction in them is plane and weak. Accordingly, the cryocrystals more than other solids satisfy the favorite theoretical models and provide ideal objects as concerns the investigation into the most critical problems of solid-state physics like those of lattice dynamics, phase transitions, lattice defects, elementary excitations, physics of solid solutions, oriented glasses, *etc.*

Today, the cryocrystals, including their solid-solution forms, are increasingly applied in engineering, particularly, in the

cryogenic or spacecraft equipment (cold accumulators or regenerative expansion systems);

experimental nuclear physics (as the constituents of gamma-radiation gages);

fusion reactors (producing high-temperature plasma with the use of solid deuterium);

as energy-storing substances or oxidants (solid hydrogen, methane, oxygen, or fluorine);

as the working bodies in ultrahigh-power lasers; or

as the low-temperature conductors of hydrostatic pressure.

To make possible efficient application of the cryocrystals, a comprehensive system of the experimental data on their physical properties is required.

Early as in the 1930s, investigations began into the physical properties of the cryocrystals, including their solid-solution alternatives. Starting from the 1960s, complex systematic studies were conducted of the structure and the thermodynamic, acoustic, and spectroscopic properties. The studies were predominantly done in the Ukraine, in the Physical-Technical Institute of Low Temperatures, National Academy of Sciences (NAS) of the Ukraine, Kharkov Physical-Technical Institute, Donetsk Physical-Technical Institute, and Institute of Physics, NAS of the Ukraine. Likewise, leading physical laboratories of Russia, USA, Great Britain, Germany, Japan, Canada, *etc.* performed the investigations. The investigation results were published in hundreds of scientific papers and generalized and discussed in monographs and handbooks:

Rare Gas Solids, Klein, M. L. and Venables, J. A., Eds., Acad. Press, London–New York–San Francisco, 1977;

Cryocrystals, Verkin, B. I. and Prikhod'ko, A. F., Eds., Naukova Dumka, Kiev, 1983;

Physics of Cryocrystals, Manzhelii, V. G. and Freiman, Yu. A., Eds., AIP, New York, 1996;

Roder, H. M., *et al.*, Survey of the Properties of the Hydrogen Isotopes below their Critical Temperatures, NBS, *Technical Note 64 1*, U. S. Government Printing Office, Washington, DC 20401, 1973;

Eselson, B. N., *et al.*, *Properties of Liquid and Solid Helium*, Standart Publ. Co., Moscow, 1978;

Eselson, B. N., *et al.*, *Properties of Liquid and Solid Helium: ^3He – ^4He mixtures*, Naukova Dumka, Kiev, 1982;

Verkin, B. I., *et al.*, *Handbook of Properties of Condensed Phases of Hydrogen and Oxygen*, Hemisphere, New York, 1991;

Manzhelii, V. G., *et al.*, *Binary Solution of Cryocrystals*, Begell House, New York, 1996;

Manzhelii, V. G., *et al.*, *Structure and Thermodynamic Properties of Cryocrystals*, Begell House, New York, 1998;

and other publications.

However, the data on the mechanical properties, including elastic characteristics, are quite scarce in those books.

In the present handbook, the literature data are generalized and critically assessed on the characteristics of mechanical behavior (the strength and ductility values under, compression, tension, impact bending, extrusion, indentation,

creep, *etc.*) and elastic properties (Young's modulus, Poisson's ratio, and elastic constants) of the most plane molecular crystals. The book involves the data published until 1998. Plus to this information, the data are given on the dislocation density, dislocation mechanisms, and thermal-activation characteristics (activation energy and activation volume) of plastic deformation of the cryocrystals. Quite often, nonstandard techniques or facilities were developed and used by the researchers for growing or testing of the specimens. Therefore, we describe some of those techniques and facilities in the handbook. We believe hope that thereby we help the users of the book to apply some of those technical solutions in the professional activity and, as well, to facilitate the appreciation of the delivered data itself.

Compiling the handbook, we partly adopted the information on the plasticity and elasticity of the cryocrystals involved in the above monographs. Yet it is original works that the general piece of the data was taken from. We basically give the quantitative experimental data in a tabulated form. And we use graphs (figures) to represent in general the cryocrystal strength, ductility, or elasticity as dependent of various physical parameters.

The author is humbly and with buoyant feelings dedicating this piece of work to the memory of his parents, Ivan Akimovich Prokhvatilov and Efrosin'ya Maksimovna Prokhvatilova, as well as of Academician Boris Ieremievich Verkin, the founder of the Khar'kov Physical-Technical Institute of Low Temperatures, Academy of Sciences of the Ukraine. Academician B. I. Verkin permanently paid his lively attention to and supported by all means the studies into the physics of the cryocrystals, which were being conducted in the Institute.

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