Glasses coming into sharper focus

Physics of Amorphous Materials

S. R. Elliott

386 pp. Wiley, New York, 1986.
ISBN 0-470-20472-9. $65.95

The Physics of Amorphous Solids

Richard Zallen

304 pp. Wiley, New York, 1983.
ISBN 0-471-01968-2. $42.95

Reviewed by Kishin Moorjani

Amorphous materials, their science and their technology, have finally come of age. A legitimate question would be, why so late?

There are several reasons for this late flowering and recognition. One is the preponderance of terrestrial minerals that originate from the slow cooling of lava. The ubiquitous presence of water reduces the viscosity of terrestrial magmas and increases the diffusion rate for oxides dissolved in them, thus favoring the growth of crystals. Because of the rarity of water on the moon, one finds, in contrast, only a few minerals but many types of glasses. Undoubtedly, astrogeologists will have to acquire a greater knowledge of glasses and a lesser knowledge of minerals than their terrestrially focused colleagues.

In spite of the relative abundance of crystalline materials, there was a fair amount of interest in amorphous solids till the discovery of x-ray diffraction by W. H. and W. L. Bragg in 1912, which directed the attention of physicists to crystalline solids for the next two generations. The resulting profusion of experimental data combined with the predilection of science for simplicity of formulation made crystalline materials primary in the eyes of physicists. With quantum theory a theoretical framework—based on Felix Bloch's theorem for a periodic lattice and the concept of reciprocal space—emerged.

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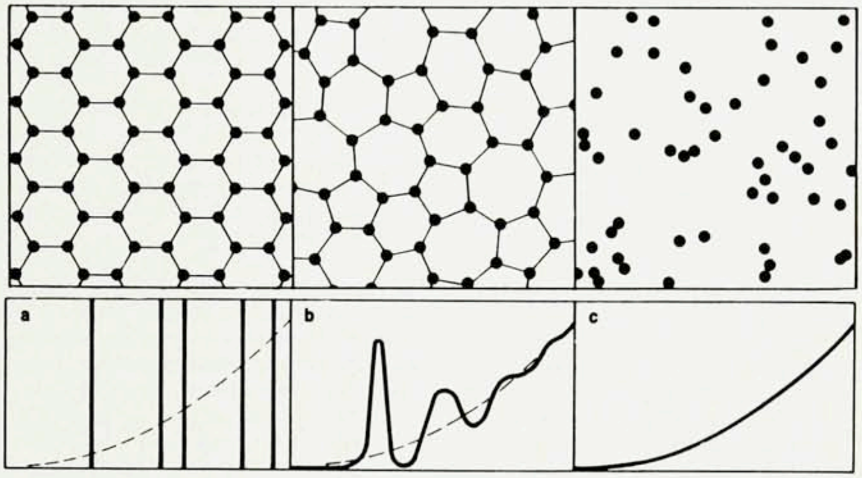

Schematic sketches of the atomic arrangements (top) and the radial distribution functions (bottom) in (a) a crystalline solid, (b) an amorphous solid, and (c) a gas. The figures appear in *The Physics of Amorphous Solids* and are reprinted by permission of the publisher.

However, the fact that many phenomena are essentially unaltered by the absence of a periodic lattice has forced a reappraisal of the existing theoretical framework. The conundrum has obliged physicists to deepen their understanding of solids, leading them to better appreciation of chemical concepts, and of the relation between bonds and bands. Combined with the novel phenomena induced by disorder, the stage is now set for intense activity in amorphous structures. The revolution is not confined to materials but extends to geology, to biology (where disorder abounds), and to mathematics with its recent interest in fractals and chaos.

The two monographs under review are by authors preeminently qualified to write on the subject, both having contributed copiously to amorphous semiconductors. The titles of the books notwithstanding, the subject matter is essentially confined to amorphous semiconductors, though the volume by Elliott does contain a chapter on amorphous metals and allusions to metals are also to be found in the book by Zallen. Metallic and magnetic glasses constitute large disciplines within the amorphous domain and at this stage, it is perhaps too much to expect single slim volumes to come to grips with the subject in its entirety.

The two books cover essentially the same areas dealing with formation and atomic structure of glasses (see figure), their electronic and vibrational properties, and the intriguing and important concept of defects in amorphous structures. The emphasis, style and degree of coverage, however, are quite different in the two volumes. Elliot's book is approximately 50% larger than Zallen's and therefore accommodates more experimental data and theoretical details. Zallen's monograph is more conceptually oriented and includes an excellent chapter on the percolation model that can be profitably read even by students and researchers whose immediate interests lie outside the field of amorphicity.

The texts on crystalline solids invariably commence with a description of periodic structures and generally contain not a clue as to the preparation of crystals. The trend for monographs on noncrystalline solids, pursued by both