letters

Noncrystalline semiconductors

Hellmut Fritzsche has performed a useful service in reviewing much of the recent scientific literature on noncrystalline (particularly amorphous) semiconductors (October, page 34). His treatment of the historical background of this field, however, unfortunately omits some significant references and contains some dubious ascriptions.

His reference to "the inventive drive that utilizes the unique properties of amorphous semiconductors and that gave this field its original momentum" is to Stanford R. Ovshinsky, in *Physical Review Letters* **21**, 1450 (1968). While the publication of this letter provoked a large increase in research activity in the field and helped bring it into the mainstream of solid-state physics, it is also true that, by 1968, two multibillion-dollar industries had already profited for some 20 years from the introduction of amorphous photoconductors into the field of office copiers[1] (1948) and television camera tubes[2] (1951).

The 1968 paper by Ovshinsky describes an electrical switch using amorphous materials. It was described in the *New York Times* as comparable in importance with the transistor. Nevertheless, its commercial impact at the time was minimal and now appears to have practically disappeared. The commercial impact of the amorphous photoconductors in office copiers and television camera tubes, on the other hand, has been outstanding and continues, even after almost 40 years, to increase.

Perhaps the most unfortunate omission in the paper by Fritzsche is any mention of the first demonstration of a solar cell (1976), by David E. Carlson and Christopher R. Wronski using hydrogenated amorphous silicon.[3] This paper initiated a worldwide effort on the science and technology of amorphous silicon. Carlson's and Wronski's contribution was recognized in 1984 by the IEEE with the award of the prestigious Morris Liebmann Prize. Fritzsche himself, on an earlier occasion, paid tribute[4] to this work.

In brief, Fritzsche's treatment of the historical aspects of amorphous materials in the PHYSICS TODAY article is not in keeping with his knowledge and standing in the field.

References

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THE AUTHOR COMMENTS: I am grateful to Albert Rose for giving me the opportunity to point out the tremendous impact that the first amorphous silicon solar cell of David E. Carlson and Christopher R. Wronski had on our field. I do not know how it is possible that I omitted mentioning this important milestone in my article on noncrystalline semiconductors. I very much regret this mistake and apologize.

With regard to the use of noncrystalline semiconductors in xerographic office copiers and television camera tubes, I have often wondered why some materials applications strongly stimulate materials research while others do not. The reversible and very fast switching effect described by Stanford R. Ovshinsky in his *Physical Review Letter* made a strong impression on many of my colleagues, and on me, because we realized how little we knew about this huge class of materials of which these noncrystalline semiconductors are only a part. It changed the direction of our research because of its intellectual challenge and not because of its commercial utility.

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Superpolymers

The excellent article on superpolymers and colloidal aggregates by Tom C. Lubensky and Philip A. Pincus in a recent issue of PHYSICS TODAY (October, page 44) draws attention to a growing area of research[1] on supramolecular

systems in which physicists have an important role to play. As methods to produce well-controlled colloidal crystals are developed[2] and instrumental techniques to study their behavior under nonequilibrium conditions are refined,[3] the study of the static and dynamic structures of such supramolecular assemblies offers additional opportunities to understand many-body interactions. The possibilities of translating these to interactions in molecular systems are also promising.

I hope that PHYSICS TODAY will continue to highlight these and related areas of physics, such as the series of articles on fluids out of equilibrium,[4] in its future issues. In this context, your readers may also be interested in a forthcoming symposium[5] on the statistical mechanics of micellar and microemulsion systems, scheduled for the spring 1985 meeting of the American Chemical Society.

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Why is there an arms race?

Your July editorial (page 128) was correct in that physicists can contribute to greater understanding of the arms-control problem. But, while the technical aspects are important, understanding the political and emotional forces involved is more important, and these influences should not be obscured by physics problems. Why *is* there an arms race?

All policies are mixtures of both rational and irrational decisions, foolishness and (in some cases) wisdom; but they are often more irrational, more foolish and more unconscious than they are rational, wise and conscious. There are many examples of the irrationalities that spur the arms race:

▶ Early man probably relied on those close to him (who also carried his genes) for protection and support while others posed a danger. The need to belong, to be in a group, is basic. But for in-groups to exist, there must be out-groups. People need outsiders, aliens, unaccepted "others." Does anyone doubt that if Earth were invaded, the US and USSR would drop their rivalry to fight the invaders? We would become parts of the same in-group, for there would be outsiders to define it.

▶ People need friends, but they also need enemies—people to love and people to hate. The history of the US (or any other great state) is, in part rationally, a kaleidoscope of friends and foes. Yesterday's bitter enemy is today's close friend. The identity changes, but one thing is constant: the existence of enemies. They fill a basic human need.

▶ Emotions, strong emotions, are rewarding. Humans crave excitement. Which is more exciting, war or peace? Huge machines (toys) or education? The new or the old? Fighting or negotiating? Action or thought? Victory or compromise? Intricacy or simplicity?

▶ We react not to things but to what they represent as symbols. Why do people lose their temper if the flag is damaged? It is only a piece of cloth. But symbols have emotional content in that they summarize and substitute for things otherwise too large or too abstract for us to comprehend. So we fight for these symbols, even at the expense of that which they represent.

▶ Arms have emotional content—they are not only useful, but enjoyable. And they are symbols for values of great emotional content: power, pleasure, pride, patriotism, toughness, self-righteousness, moral superiority, emotional security, stability, glory, excitement. They are a form of group identification and wish fulfillment and an escape from both subtlety and complexity.

▶ It is common for people to develop methods to reach goals and then become so involved with these means that they not only lose sight of the end but also become so obsessed that they are happy to accept an outcome that is the complete opposite of their original goal (the means justifies the end). What is more important: national security or lots of enjoyable weapons—even if they threaten national security?

▶ A major reason for the current arms buildup was the Iranian hostage situation. However, more weapons would not have helped there, and the arms now being acquired are aimed not at Iran but the Soviet Union. An analysis of this explains much about arms races.

▶ Logically arms should be obtained for use (even if only as a deterrent) the way money should be obtained to buy things. But money is often acquired