MAGNETIC ENGINEERING

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The subject of magnetism encompasses a wide range of phenomena—from the theoretical world of critical behavior and heavy fermions to the applied world of magnetic recording and permanent magnets. This breadth has both positive and negative aspects. On the positive side, the concepts at one end can be applied throughout the spectrum to solve seemingly unrelated problems at the other end. For example, the theory developed to describe spin systems subject to random magnetic fields has recently been applied to explain the behavior of "real" (that is, atomically rough) magnetic interfaces encountered in magnetic sensors. On the negative side, the practitioners at one end of the spectrum often do not appreciate the value of activities at the other end.

What should the strategy be for training students in applied magnetism? The purists argue that the field is best served by providing students with strong training in condensed matter physics. The idea is that this would attract "the best and the brightest," some of whom might eventually move into applied areas or be directly hired to work on those areas by "enlightened" employers. This argument is analogous to suggesting that we rely on the nuclear physics community for our nuclear engineers. History does in fact show that physicists often bring an approach to engineering problems that results in major contributions. However, as one moves toward the more applied end of the spectrum, the problems become more interdisciplinary and tend to depend heavily on the investigators' experience for their solution.

Magnetic recording, for example, involves physics, materials science, tribology and information theory in challenging combinations. The question of how a small but macroscopic region of a magnetic medium reverses its magnetization may sound like a classical problem. However, its solution, which governs the ultimate rate and density at which the medium can store data, will very likely require new developments in the dynamics of finite systems. The industry based on this technology is undergoing tremendous growth—by about 20% per year—and it has not been possible for the US industry to rely on the nation's condensed matter physics community in order to remain competitive. In fact, the whole field of magnetics has largely been ignored by the US science community.

In 1985 the National Academy of Sciences sponsored a study of magnetic materials in the US through the National Materials Advisory Board. The results of the study (PHYSICS TODAY, October 1985, page 20) showed that although magnetic technology is critical to our economic and strategic well-being, we are rapidly losing our ability to compete. More recent workshops at Purdue University (sponsored by the Office of Naval Research) and in San Diego (sponsored by the Defense Advanced Research Projects Agency) reached the same conclusion. Although all these studies have identified scientifically challenging issues, the funding agencies have been slow to respond. In the early 1970s the Department of Defense sponsored the VHSIC program to accelerate the development of submicron semiconductor technology for very-high-speed integrated circuits. A similar program in magnetics would certainly revitalize this industry. Some of us believe that magnetism, as a result of new materials and the new spin-dependent analysis instruments, is about to enter a renaissance similar to what we have witnessed in semiconductor physics over the past five or ten years.

Although the magnetic recording industry itself is comparable in size to the semiconductor industry, many of the companies that make up this industry, with the obvious exception of IBM, are small and lack the resources to provide the breadth of training that the underlying technology demands. For this reason, several of these companies—including IBM—have contributed financially to the formation of what I think should be referred to as "magnetic engineering" centers at Carnegie Mellon University, the University of California at San Diego and Santa Clara University.

But I believe much more is needed to make the US competitive in this area. We might take some lessons from the semiconductor industry. It not only has a strong trade association in Washington, but also has developed innovative funding mechanisms to support research. The Semiconductor Research Corporation strategically distributes research funds from 35 corporations to 43 universities. One of the goals, for example, is to stimulate the semiconductor industry to have 256-Mbit dynamic random-access memory chips available by 1994.

A similar new initiative on the part of the magnetics industry would make research funds available to an academic base broader than the current three universities. Another approach would be a research consortium along the lines of the Microelectronics and Computer Technology Corporation, formed by approximately 20 companies to promote research in support of fifth-generation computer technology.

Whereas research at the "basic" extreme of the magnetics spectrum may affect the way we think about condensed matter, research at the applied extreme may affect the whole computer industry and, therefore, our ability to solve basic problems. These two activities—and many in between—are essential to each other's vitality. Magnetic engineering should be viewed as an opportunity to bring these areas together and revitalize a discipline of physics in which the US has historically contributed so much. ■

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