Meetings

Ceramics

The upheaval that results when a useful discipline, rooted in antiquity and with a well-developed body of empirical knowledge, is overrun by modern technology is well-known to many scientists. Metallurgy came under the spell of physics many years ago, with revolutionary results. Few can doubt that the entire discipline has profited handsomely.

Anticipating that ceramics can be similarly revolutionized by physics and chemistry—and that in the process some vexing materials problems can be solved—the Office of Naval Research organized a symposium on the physics and chemistry of ceramics. It was held at the Pennsylvania State University from 28 to 30 May, with about 65 invited ceramists and solid-state physicists in attendance.

As noted in the prospectus, the purpose of the symposium was twofold: (i) to review the principles of solid-state physics and solid-state chemistry that are applicable to ceramics research and education today, and (ii) to examine mechanisms by which ceramics curricula can be made more responsive to the future needs of ceramics.

The first of these objectives was attained in notable fashion; rarely have so many people participating in the growth and development of the "new" ceramics come together to discuss current research. One had to conclude, however, that ceramics curricula at most universities are not at present geared to the needs of the time. Nor did the panel of ceramist-educators which closed the conference agree on what road should be taken. Yet it is safe to say that a ferment has been raised in every ceramics department in the nation.

It was fitting, indeed, that the stage for the symposium should be set by Frederick Seitz, coauthor of the Wigner-Seitz theory that lies at the heart of the physics of solids. However, his duties as newly elected president of the National Academy of Sciences prevented him from attending and his long-time associate at Illinois, R. J. Maurer, read the Seitz paper.

In it Seitz traced the flow of discovery during the last 100 years in the science of solids—from the delineation of macroscopic properties, through the concepts of the crystal lattice and the electronic structure of the perfect crystal, to the theory of imperfections—and discussed future study of the surfaces of solids. He found that metallurgists had been quicker to embrace the new knowledge than ceramists—that metallurgists took the challenge directly from the physicist, whereas ceramists usually waited for additional development by the chemist. He suggested that the ceramist accept the physicist on the latter's terms as a partner in instruction and research, much as the metallurgist has done.

W. R. Buessem, of Pennsylvania State University, then took up the problems the ceramist presents to the physicist. The ceramist, he said, is concerned with an empirical body of knowledge that is entirely adequate for most ceramic applications but represents only a gross approximation for the purposes of the solid-state physicist. He suggested that physicists should give the polycrystalline structure the same attention that they have given the incomparably simpler single crystal. Ceramists, in turn, can support this work by developing methods to manufacture pure and ultrapure materials, and by identifying the crystallites in the ceramic body with those which the physicist is using in his studies.

Buessem noted that a comparison between the properties of a material in single-crystal form and in the form of pressed powders or fired ceramic bodies is one of the most interesting avenues of research today. The lively discussion which followed Buessem's paper confirmed this statement, and many suggestions were made for obtaining polycrystalline samples. It was proposed that single crystals be crushed to pieces and put back together again, like Humpty Dumpty; that twinned or polycrystalline ingots be grown; or that samples be pressed and sintered from powders.

After this introductory session, 14 papers summarizing present research were given. These will soon be available in a proceedings volume, to be published by Gordon and Breach, New York.

The speakers and subjects were as follows: Leonid V. Azaroff (Illinois Institute of Technology), "Properties and crystal structure of materials"; Rustum Roy (Pennsylvania State University), "Crystal chemistry in research on ionic solids"; A. D. Franklin (National Bureau of Standards), "Impurity controlled properties of ionic solids";

Donald S. McClure (R.C.A. Laboratories), "Colors and spectra of transition-metal ions in ceramics"; H. G. Drickamer (University of Illinois), "Effect of pressure on the electronic structure of solids"; C. E. Birchenall (University of Delaware), "Diffusion in ionic crystals"; J. E. Burke (General Electric Research Laboratory), "Science and technology of sintering"; R. J. Maurer (University of Illinois), "Optical properties of ionic crystals"; H. C. Gatos (Lincoln Laboratory, M.I.T.), "Electrical properties of semiconductor materials"; L. R. Bickford, Jr. (I.B.M. Research Center), "Magnetic properties of ceramics"; John J. Gilman (Brown), "Electrons, dislocations, and the strength of ceramic crystals"; Roger Chang (Atomics International), "High-temperature mechanical behavior of ceramics"; W. D. Kingery (M.I.T.), "Effects of microstructure on the properties of ceramics"; and Gerald W. Sears (General Dynamics Electronics), "Nucleation and crystal growth."

Gilman raised the possibility of obtaining ceramic materials with ultimate strengths of 5 million pounds per square inch, ten times stronger than steel. This, he said, can be done if we learn how to make single-crystal materials in which the dislocations do not move. "The monocrystalline form is important because of the intrinsic weakness of boundaries between such crystals," he said. The dislocations must not move because it is through the motion of dislocations that yield takes place, resulting ultimately in rupture. While probably no large structures could be made of single-crystal materials, such materials would be very useful for certain critical applications—for example, the manufacture of small-size objects such as high-pressure vessels, ultracentrifuges, gyroscopes, and magnets. The carbides of the transition metals or the light elements will be the strongest compounds for such applications.

Cyrus Klingsberg, ceramist in the metallurgy branch of the Office of Naval Research, who organized the symposium, discussed federal sponsorship of research in ceramics. He stated that only $15.8 million out of $9.6 billion spent annually for research could be clearly identified as spent for ceramics research, notwithstanding the critical need for new ceramics materials. He held both the ceramist and the government scientist in some degree responsible for this low level of support. On the one hand, the ceramist is primarily oriented toward the problems of industry, his research shows less breadth and imagination than research in other fields, and it is devoted primarily to making the most of the properties of known materials. On the other hand, the government funding agencies have shown much less interest in the problems of ceramics than in those, say, of metallurgy and have committed insignificant sums for the improvement of ceramics materials as compared to the huge investments in metals research. If the wall is to be breached, the ceramist must embrace the "new" ceramics and the funding agency must provide support commensurate with the potential rewards.

The wind-up panel on ceramics education focused on the problems of preparing bachelor's degree candidates to meet the needs of the ceramics industry and of conducting meaningful research at the graduate level to train an entirely different breed of ceramists. It was clear that not all departments have solved this problem, and in fact that none had solved it in its entirety. Participating in this discussion were G. W. Brindley (Pennsylvania State University), chairman; R. L. Coble (M.I.T.); R. L. Cook (University of Illinois); I. B. Cutler (University of Utah); V. D. Frechette (Alfred); J. E. Mueller (University of Washington); J. A. Pask (University of California, Berkeley); R. Russell, Jr. (Ohio State University); and R. L. Sproull (Cornell).

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Forthcoming Events

December

1. New York State Registry of **Medical Technologists**, annual seminar, New York. (S. H. Keeling, 1719 Midland Ave., Syracuse, N.Y.)

2–4. American **Pomological** Soc., Yakima, Wash. (G. M. Kessler, Dept. of Horticulture, Michigan State Univ., East Lansing)

2–6. American Inst. of **Chemical Engineers**, Chicago, Ill. (F. J. Van Antwerpen, AICE, 345 E. 47 St., New York 17)

3–4. **Satellite Communication**, intern.