Meetings

Crystal Films

In recent years a considerable amount of technical and scientific literature has been published on the subject of thin films. Much of this has dealt with physical (electrical, magnetic, and optical) properties and with the evaluation of films for solid-state components. In order to discuss various aspects of this complex field, a conference was held at Philco Scientific Laboratory, Blue Bell (13–15 May). Scientists from the United States and abroad attended the meeting.

In one important class of materials (for example, semiconducting elements and compounds), films in single-crystal epitaxial form have found wide utility, and their properties in relation to the needs of active devices have been fairly well characterized. The present trend in electronics technology, however, is toward devices which comprise combinations of films such as metals and insulators that possess a variety of special characteristics (for example, magnetic hysteresis, high dielectric capacitance, superconductivity, and so forth). Although the tailoring of these film components to the requirements of microcircuit assemblies is often critical, our knowledge of the factors that govern their behavior is still very obscure.

The conference, with reference to its bearing on the technology of solid state components, was concerned with the following main themes: (i) the problems of how those films commonly used in the fabrication of new devices nucleate and grow on both amorphous and single crystal surfaces, (ii) the need for clean surfaces and high vacuums in order to obtain reproducible growth and structural data on thin films, particularly those with single-crystal structures, (iii) novel preparative techniques such as cathodic sputtering and flash vaporization suitable for the epitaxial growth of semiconductors or alloys in standard vacuum systems, and (iv) the need for making physical measurements on single-crystal films which are as free from structural defects as possible. Such measurements may prove vital in arriving at a systematic evaluation of the ultimate potential of thin films in new miniature components.

Detailed discussions dealt with general problems of the initial nucleation and growth of thin films of various materials ranging from metals to insulators and compound semiconductors. New theoretical and experimental work on the potency of macroscopic steps as nucleation catalysts was cited. Recent experiments which provide new evidence on the role of substrate perfection and atmospheric contamination were described, and new data were presented on the electrical, optical, and magnetic properties of single-crystal films grown by epitaxy on crystal substrates.

It is anticipated that the conference will play an important role in highlighting the fundamental problems of thin-film structure and in demonstrating the importance of making physical measurements on films in which the structural orientation and perfection are properly characterized. Sponsors of the meeting included: Advanced Research Projects Agency, Office of Naval Research, Philco Corporation, Princeton University, and the University of Pennsylvania.

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Surface Physics

A group of scientists interested in the physics of surfaces heard four invited speakers present papers on their latest work at a symposium at Washington State University (17–18 May).

Even though "vacuum measurements" were not presented, it is inevitable when vacuum workers get together that thoughts turn to pressure measurements and the accepted standard at low pressure—the Bayard-Alpert ionization gauge. Alpert developed the inverted gauge structure in 1950 and showed that the low pressure limit was reduced from 10^{-8} to 10^{-11} torr by reducing the collector size and the corresponding photoelectric effect at the collector. He showed that the improved performance at low pressure was still limited by a small photoelectric current caused by x-rays striking the collector.

The Bayard-Alpert gauge is simple in principle and in operation; electrons collide with gas molecules, and the resulting ions are collected. The collector current is proportional to the pressure in the gauge if precautions are taken to keep constant the electron current, gas composition, fields, and so forth. Recent unexplained or anomalous nonlinear behavior has been noted for these gauges when they are operated at low pressures in the presence of active gases. Two of the papers at this symposium suggested possible causes of this behavior.

P. A. Redhead (National Research Council of Canada) spoke on the interaction of electrons with chemisorbed layers of gases. He has found that when electrons bombard a molybdenum surface covered with oxygen, ions of oxygen are released with an efficiency of 10^{-5} ion per electron, while neutral oxygen is released with an efficiency of 10^{-3} atom per electron. If ions were released from the grid of an ionization gauge by this mechanism, they would register as ion current and make the gauge reading incorrect.

D. R. Denison (Washington State University) described another effect which may produce incorrect ionization gauge readings. He showed that when a filament is heated in active gases, it is chemically sputtered and releases positive ions and neutral impurity atoms originally present in the filament. The neutral atoms could travel to the grid and be desorbed later as ions by electron bombardment. This would produce a collector current not related to pressure in an ionization gauge.

Yet another possible source of contaminants is the glass wall of the gauge. Thermal decomposition or physical sputtering of the glass could deposit impurities on the grid from which they may later be desorbed as ions. All of these effects show that the low pressure limit of the Bayard-Alpert ionization gauge is a more complex problem than was believed before.

One of the high points of the 1961 vacuum symposium in Washington, D.C., was a report by Lange and Riemersma (Westinghouse) on the desorption of carbon monoxide and nitrogen from a nickel ribbon by means of photons. This was an especially interesting idea because photodesorption allowed the energetics of adsorption to be studied by optical methods. Lange spoke on his later work at this symposium. Using a dynamic vacuum system, he found about the same peak efficiency (10^{-8} molecules per photon) of photodesorption for carbon monoxide on tungsten as on nickel if the tungsten is flashed clean immediately before desorption. The photodesorption competes with a strong thermal desorption when high gas coverage is used.

R. O. Adams (Washington State University) has used a closed vacuum system to study photodesorption from evaporated metal films and from ribbons. His photodesorption measurements for films and ribbons of nickel covered with carbon monoxide yield resonance curves similar to those of Lange with a peak value of 10^{-7} atom per photon at 3000 Å. Attempts to desorb oxygen from iron films gave no detectable results at room temperature but gave detectable photodesorption at $-50°C$. No photodesorption could be detected for radiation from 5700 Å to 2537 Å when molybdenum or tungsten ribbons were covered with carbon monoxide, carbon dioxide, nitrogen, or hydrogen.

An interesting result was obtained with carbon dioxide on nickel. When gas was adsorbed on a cold ribbon, photodesorption did not occur but when a nickel ribbon was heated to 1000°C and then cooled in 10^{-6} torr of carbon dioxide, photodesorption occurred. Carbon monoxide was probably produced from carbon dioxide at the hot surface and adsorbed as the ribbon cooled.

R. L. Jepsen (Varian Associates) showed that pumping or removal of gas can result from the presence of ionizing discharges or from the deposition of getter films. When these two processes are combined in a single enclosure, the total removal rate for a large number of individual gases seems to be the sum of the adsorption rates due to each process considered separately.

A description of an exotic gettering experiment was presented by A. L. Hunt (Lawrence Radiation Laboratory). A copper surface is cooled to 11°K and a layer of getter gas is condensed on this surface. When hydrogen is allowed to strike the condensed gas surface, it is adsorbed with a sticking probability approaching unity in some cases. This is just one of the cryopumping experiments that have been conducted in the search for cleaner vacuum for Project Sherwood.

On the evening of 17 May, former students and friends of Paul A. Anderson gave a banquet honoring his contributions to surface physics. His pioneering measurements of work functions for clean surfaces made in the 1930's and 1940's were acknowledged.

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Radiation in the Natural Environment

The widespread interest in the effect on the human population of its continuing exposure to natural radiation was the basis for a symposium held at William Marsh Rice University, Houston (10–13 April). More than 120 scientists from 14 countries attended in order to discuss their wide-ranging interests in natural radioactivity and radiation and the methods used in their studies.

A cross-calibration of the instruments used by various groups for measuring natural radiation was carried out. These instruments include air- or tissue-equivalent and high-pressure ionization chambers, portable scintillation detectors, gamma spectrometers, and an aerial monitoring system. Measurements were made at locations on the Rice University campus, at the Galveston beach, and on a pile of zircon sand at a local tin smelter. Preliminary calculations indicated agreement within a range of 10 percent for the measurements made on the ground with ionization chambers. The results of these intercalibrations are expected to be published as an appendix to the printed proceedings.

The many varied aspects of the natural radiation environment which were discussed at the meeting included airborne, surface, and subsurface instrumentation and measuring techniques; geologic and geochemical studies of the natural radioactivity of bedrock types, soils, and broad regions; measurement of the radioactivity in air, water, and soil; the properties of the cosmic radiation, with particular emphasis on the neutron component and its possibly significant dose contribution; and regional studies of natural radiation levels in Brazil, West Germany, India, Niue Island (New Zealand), Spain, the United Kingdom, and the United States.

Several research groups in different countries have developed portable ionization chambers and gamma spectrometers that are quite suitable for quantitative dosimetric studies of natural environmental radiation, but the formidable problems associated with making precise measurements of low-level radiation fields with portable instrumentation were emphasized.

Because of the difficulties associated with the measurements, there is considerable uncertainty as to the dose contribution of the cosmic ray neutron component. Further work in this field would be most useful.

There appear to be only a few areas, including the well known regions in Brazil and India, where large populations are exposed to external natural radiation levels which are above normal by an order of magnitude or more. The study in Brazil involves the analysis of biological samples to provide estimates of ingestion of radioactivity and measurements of population exposure to external radiation.

The difficulty in applying geological data on radioactivity of bedrocks in order to estimate population exposure to natural gamma radiation was emphasized. Radioactivity in soils and man-made structures is generally the main source of this radiation exposure, and these sources may have only an indirect relationship to the underlying bedrock.

Population exposure to internal sources, particularly alpha emitters, is not necessarily directly related to the external gamma radiation environment and in many cases may be much more significant. The ingestion of natural alpha emitters varies by at least a factor of 100 for large human populations.

Several effects causing significant time variations in natural gamma radiation levels were brought out; particularly emphasized was the migration of radon and its daughters out of the upper layers of the soil and the "natural fallout" of the gamma-emitting daughters from the atmosphere. The observable effect of rainfall and snow cover on the gamma levels was also noted.

A number of papers dealt with the determination of exposure levels of large populations to natural radiation,