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ELECTRON DIFFRACTION INVESTIGATION

OF

PHOTOCONDUCTIVE CRYSTALLINE LEAD SULFIDE SURFACES

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Project 2037

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ELECTRON DIFFRACTION INVESTIGATIONS OF PHOTOCONDUCTIVE CRYSTALLINE LEAD SULFIDE SURFACES

INTRODUCTION

On 20 August, 1951 Professor Brockway was asked by the Physical Sciences Division of the National Research Council to consider whether electron diffraction methods could offer material assistance in a fundamental study of the properties of photoconductive lead sulfide films, with the understanding that the then Commanding General of the Air Research and Development Command of the U. S. Air Force had requested the National Research Council to suggest research projects suitable for support by the Air Force. After consultation with Professor Brian O'Brien of the Institute of Optics at the University of Rochester and Professor G.B.B.M. Sutherland of the University of Michigan and after examination of the literature, Professor Brockway concluded that no systematic study had ever been made of the composition and structure of partially oxidized lead sulfide surfaces in relation to variations in the method of preparation and in the physical properties of the films. Since this aspect of the problem is important for a fundamental understanding of the behavior of the films and since it is susceptible to study by electron diffraction and microscope methods, a proposal was drafted. After review by the Physical Sciences Division of NRC, it was submitted to ARDC in October 1951.

A tentative agreement was reached with an experienced electron diffraction investigator to work full-time on the project. After three months he could wait no longer and withdrew. No further efforts were made to obtain personnel in the absence of a contract.

On 14 January, 1952, Purchase Request No. 264865 was received, the proposal was re-submitted on 23 January, and contract AF 18(600-175 was signed as of 29 February, 1952.

ACTIVITIES UNDER THE CONTRACT

Equipment

As provided in the proposal and the contract, orders were placed for an RCA electron diffraction unit and a high vacuum evaporator.

The diffraction unit required as a replacement for a similar unit in this laboratory was delivered on 28 April and has been assembled, tested, and placed in operation. It has been used for preliminary work in the investigation of lead sulfide surfaces. It has also been used extensively to date in connection with Project 2020 under Air Force Contract No. AF 33(616)-23, E.O.No. R463 Br-1, Development of Procedures for the Identification of Minor Phases in Heat-Resistant Alloys by Electron Diffraction, a project which has been very productive.

The high-vacuum evaporator was delivered on 28 July and placed in operation for preparing condensed films of lead sulfide and surface replicas for electron microscope examination.

Personnel

After the contract date, negotiations were renewed for an experienced full-time investigator for the project. By that time the only source was graduate students with x-ray and electron diffraction training who expected to receive Ph.D. degrees in June 1952 or later. Offers were made to several men amounting to $6000 a year, with thirty days' leave, a top figure in academic laboratories for new Ph.D. research men, since the 50 per cent differential above new instructors is barely tolerable. The competition with industrial research laboratories for trained men has been especially keen in 1952; many current Ph.D. graduates in physics and physical chemistry have taken jobs with starting salaries ranging from $7500 to $8500. The freedom of academic laboratories, including free publications of results in particular, is the advantage that universities can offer to offset the higher salary in industry.

Two promising candidates (from the Polytechnic Institute of Brooklyn and Iowa State College, respectively) were still considering the position when the demand described below was made in early June that the present contract be classified and publication of results be restricted. In fairness to the men it was admitted that the classification status of the contract had come under question, and they immediately accepted industrial jobs.

In this situation it has been impossible to interest fully trained men; the prospect of working at a reduced salary without the advantage of enhancing professional reputation through publications is without attraction. The alternative is the assignment of one or more graduate students still in training with a correspondingly lower rate of progress on the project. One graduate student and one part-time assistant have been assigned to the project as of 15 September, 1952.

In the meantime the project supervisor and other laboratory personnel have assembled the equipment and made tests and adjustments for the handling of lead sulfide surfaces, using preliminary specimens.

Research Program

The third activity started on signing of the contract in addition to procurement of equipment and personnel was the setting up of a program for the initial investigations. Preliminary tests were started on the behavior of oxidized lead sulfide surfaces in electron beams with reference to charging up effects. This was to be followed by determinations of particle size in different films, of the single or multiple crystalline character of the particles, of the chemical composition, and of the extent to which oxidized phases cover the particles. Later work was planned for investigation of possible preferred orientation of the lead sulfide crystals on the glass support and also of the oxidized phases with respect to the lead sulfide; the effect of introducing various preferred orientations was to be tested on films condensed onto substrates consisting of massive single crystals of nonconducting minerals.

The tests on composition, distribution of the two or more phases, particle size, and orientation need to be carried out in a manner to detect differences in these chemical and structural properties due to the changes in the procedures used in preparing the films. At the same time correlations are required with changes in the optical and electrical properties of the films. This correlation with physical properties was to be supervised and in part carried out by Professor Brian O'Brien. It was agreed that while most of the films used should be prepared in Ann Arbor it would be in keeping with sound research practice to have some discussion with, and perhaps obtain some specimens from, the two companies engaged in production of lead sulfide films, i.e., Eastman Kodak Company and Photoswitch, Incorporated.

The first visit was arranged with Photoswitch because this company already had a contract with the Air Force. On 12 June Professor Brockway met at Photoswitch, in Cambridge, with Professor Wayne Nottingham of the Massachusetts Institute of Technology, Dr. Raymond McFee of

Photoswitch, and with the president of Photoswitch. Professor Nottingham spoke for Photoswitch.

Professor Nottingham expressed surprise at the existence of the present contract and maintained that it was previously unknown to the Photoswitch contact at Wright Air Development Center. He suggested at first that the electron diffraction work of Professor Lark-Horowitz of Purdue University performed on a service basis for Photoswitch had exhausted the necessary investigation with electrons, but later agreed that a more systematic and thorough study would be required for understanding the fundamental nature of the film. A plausible theory had been based on the identification of lanarkite on certain films combined with assumptions about particle-size distribution and the distribution of the lanarkite phase.

Professor Nottingham stated further that the methods of preparation are a commercial and military secret, that Photoswitch wants to restrict publication in this field in order to maintain commercial control, that he could not see how work under the present contract could be fitted into the overall lead sulfide film program unless it were classified, and that he would ask the Air Force to classify this contract if it were continued.

It is now apparent that the request originating with Photoswitch that the present contract be classified or cancelled has been made. Classifications will so hinder the work that this laboratory would have no interest in the project in the absence of military urgency for the work.

RECOMMENDATIONS

It is recommended that this laboratory be permitted to accumulate fundamental and basic information on the composition and structure of lead sulfide films in relation to their physical properties and methods of preparation, and that publication of results be permitted while avoiding the publication of information dealing with the details of preparation of films. An agreement should be reached whereby the interests of Photoswitch are recognized without prohibiting all fundamental work in the field.