

CLOSING ADDRESSES

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Professor Muto and Fellow Participants:

This Conference has been one of the most smoothly and efficiently run conferences that I have attended. The many words of appreciation which were expressed last night at the banquet to the Organizing Committee of the Conference and to Professor Muto, its Chairman, and to Dr. Hatoyama, its very able Secretary, are echoed by all of us. The choice of the City of Kyoto and the Kyoto Kaikan for the location of the Conference was an excellent one. The Organizing Committee provided every convenience for the participants, speakers, and session chairmen, and left nothing to chance. The secretarial staff was superior in every way. The teams of people who assisted the session chairmen and took care of the mechanics of each session worked effectively and unobtrusively. The format of the Conference also reflected the excellent judgment of the Organizing Committee. The review and invited papers which preceded symposium-type sessions provided tutorial, as well as, up-to-date discussions of the important contributions in the major areas of semiconductor research.

The consensus of opinion of my colleagues is that the Program and Papers Sub-Committee did a particularly outstanding job in the selection of papers. I do not know the total number of papers that were submitted to the Committee, but I would guess that the number of papers turned down far exceeded the number of papers accepted. The Committee managed by judicious selection to limit the number of papers to 120, and to keep the number of simultaneous sessions down to two. As to the number of simultaneous sessions, I should like to point out that there were, in fact, four simultaneous sessions. The comfortable halls and lounges of Kyoto Kaikan, where discussions were held in small groups, constituted a third simultaneous session which most of us attended at various times. Such informal sessions have become a vital part of all well run conferences. The tours of Kyoto and nearby areas, which were available to the participants at all times throughout the conference, constituted a fourth simultaneous session. I, for one, found it difficult to choose between the two formal sessions and, even more difficult, to choose which formal session to forego for my own visit to Katsura Imperial Palace, one of the beautiful sites in Kyoto.

The distribution of the "short version" preprints to the participants was a splendid innovation which hopefully will be continued at future conferences. The preprints allowed us to make more satisfactory decisions about sessions to attend and largely minimized our regrets that we could not be in more than one session at a time.

In his opening address Professor Muto discussed the function of International Conferences. Among other things, he emphasized the role that such conferences play in bringing scientists from all parts of the world into contact with one another for discussions of current research. I would add to this the important element of personal excitement which I am sure all of us experience when we meet fellow scientists from other parts of the world for the first time. I recall quite vividly my first meeting with Professor E. Gross of the U.S.S.R., who was unfortunately not able to be here in Kyoto with us. This was at the 1958 Conference in Rochester. When we were introduced, Gross smiled broadly and said that he knew many American scientists at the Conference from their publications, but knew them only as printed names (this he illustrated by printing the words LAX and BURSTEIN on a nearby blackboard) and that he was delighted to be able to meet in person the people that belonged to the names. Meeting scientists from other countries continues to be an exciting experience for me, and I have been particularly pleased at this conference to meet

for the first time a considerable number of scientists from Japan and the U.S.S.R., as well as from the other countries.

I was fortunate to be one of the participants at the Second Tokyo Summer Theoretical Institute which was held at Oiso just before the present conference. At Oiso I made the acquaintance of a large number of Japanese solid state physicists and became aware of the "top-notch" research being carried out at universities and industrial laboratories in Japan. This excellence of the solid state research activities in Japan is reflected in the relatively large number of excellent papers which were presented by Japanese scientists at this conference. I should add that throughout my stay in Japan I was particularly impressed by the ability, enthusiasm, and excitement of the Japanese physicists, young and old. They have much in common with their counterparts in the United States, and I felt very much at home with them.

Another feature of the present conference which I consider noteworthy is the fact that there were lively discussions after many of the papers. The "open" discussions of papers is one of the most important aspects of an International Conference, and in my opinion is, at the least, equal in importance to the private discussions that take place outside the sessions. A lively discussion can make the difference between a "good" and an "exciting" session. Furthermore every one at the session becomes a participant in such discussions and, thereby, attains a fuller appreciation of the research being discussed. I urge the organizers of future conferences to provide adequate time for such discussions by limiting the number of papers at each session. A tight time schedule for the presentation of papers invariably discourages discussion both on the part of the participants and on the part of the chairman.

Each of us will have his own list of Conference highlights. My own list includes a number of personal as well as scientific highlights. As I have already mentioned, meeting scientists from other parts of the world is high on the list of my personal highlights. Another was the presentation of papers by two of my former graduate students, S. Iwasa and Y. Sawada, who then proceeded to top their scientific performances by singing Japanese songs at the banquet last night. I will also long remember the warm people of Japan and their beautiful country.

My list of scientific highlights is, of course, a highly subjective one and reflects the particular sessions which I attended. The highlights that come to mind at this moment include: the lively discussion of the pseudo-potential method for calculating energy bands, and the pertinent question raised by J. Yamashita regarding the ionicity of compound semiconductors in the "Band Theory" Session; the very fine theoretical paper on structure in exciton in absorption spectra by Y. Toyozawa and co-workers, and the fact that they and J. J. Hopfield, both reached similar conclusions regarding the origin of the structure in exciton spectra, although starting from different points of view; the fine experiments of H. Kawamura and co-workers on cyclotron damping of the electron active magneto-plasma waves by holes in bismuth and their interpretation in terms of non-local effects; the elegant tunneling experiments, of L. Esaki and co-workers, on semi-metals and on superconducting semiconductors; the spirited exchange between P. Handler and M. Cardona in the "Optical Properties-Electron" Session regarding the relative importance of the Franz-Keldysh effect and of the electric field suppression of excitons as mechanisms for the structure in electro-reflectance spectra; the elegant review paper by J. J. Hopfield on the concept of the polariton and its manifestation in a variety of experiments; the lively discussion regarding the selection rules for multiphoton interband transitions in PbTe following the review paper by B. Lax on Magneto-Optical Phenomena, which was continued in the "informal" session in the halls; the interesting paper by D. S. Thomas on recombination radiation associated with iso-electronic impurities; the important paper by S. M. Ryvkin and co-workers on interband transitions accompanied by the excitation of free carriers; and the very interesting paper by M. I. Cohen and C. S. Koonce on superconducting semiconductors, which was interspersed with humorous comments, such as Cohen's comment, regarding the reluctance of

physicists to believe the electrical and magnetic evidence for the superconductivity of semiconductors and their acceptance of the specific heat evidence, "It seems that everyone believes in thermodynamics."

The overall impression that one receives from the Conference is that there is an increasing sophistication in the type and scope of the research being carried out. This aspect has already been pointed out by Professor P. Aigrain in his Closing Address at the 1964 Conference in Paris. As a consequence of this increasing sophistication, there is an increasing overlap with other areas of solid state physics. During the past two years, new techniques have been developed which enable one to investigate semiconductor phenomena in greater detail. The use of differential electro-reflectance and piezo-reflectance measurements is a typical example. High resolution optical spectroscopy facilities are now available at most laboratories for the investigation of a variety of optical phenomena. Laser sources have become available in the far, as well as near infrared, and are being used for a variety of experiments such as cyclotron resonance and multiphoton interband transitions. The tunneling techniques developed by Esaki and his co-workers provide a new tool for the investigation of energy band structure of a large number of semiconductors. Highly sensitive "interference" techniques have been developed for investigating the propagation of helicon and Alfvén waves and acoustic waves. A number of high field magnet laboratories are in existence throughout the world and, together with the pulsed-magnet facilities which are now available in most solid state laboratories, are being used extensively in semiconductor research. Raman scattering has become a very effective tool for the study of polaritons and plasmons, as well as phonons, in solids. Magneto-acoustic studies are being extended to higher frequencies and higher magnetic fields, and should provide detailed information about the properties of plasmas in semiconductors. New types of materials, such as the layer-type semiconductor, GaSe, are being profitably investigated both theoretically and experimentally. The type of phenomena being investigated are also becoming more complex. There is, for example, an increasing number of optical studies in which electric, magnetic, and stress fields are applied simultaneously. We may expect to see a continuing increase in sophistication in the research being carried out on semiconductors and a greater overlapping with other disciplines in solid state physics. These will undoubtedly lead to new, interesting, and important phenomena about which we will hear at future conferences.

In closing, I would like on behalf of all the participants to thank the Sponsors and the Organizing Committee of the 1966 Conference on the Physics of Semiconductors for having assembled such an outstanding Conference, and to wish every success to the Sponsors and Organizers of the 1968 Conference to be held in the U.S.S.R.