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FOREIGN TRIP REPORT

ORNL/FTR-3147

DATE: December 19, 1988

SUBJECT: Report of Foreign Travel of O. H. Crawford, Senior Staff Member, Health and Safety Research Division

TO: Alexander Zucker

FROM: O. H. Crawford

PURPOSE: To work with Professors Y. Yamazaki and K. Komaki at the University of Tokyo on collaborative research in progress, to discuss recent research results with Professors F. Fujimoto and R. Shimizu at Osaka University, and to participate in the Symposium on Dynamic Particle-Condensed Matter Interactions at Hakone, Japan.

SITES VISITED:

11/30/88-12/02/88	University of Tokyo, Tokyo, Japan	Y. Yamazaki K. Komaki
12/04-05/88	Hakone, Japan	H. Nitta
12/06-08/88	Osaka University, Osaka, Japan	F. Fujimoto R. Shimizu

ABSTRACT: The traveler visited the College of Arts and Sciences, University of Tokyo, where he worked on collaborative research with Professors Y. Yamazaki and K. Komaki. He attended a two-day symposium on dynamic particle-condensed matter interactions at nearby Hakone and presented a paper on stopping power of crystals. He visited the Institute of Scientific and Industrial Research at Osaka University, where he conferred with Professors F. Fujimoto and R. Shimizu on research problems of mutual interest. Work was done with Professors Yamazaki and Komaki that could be quite beneficial to DOE programs of the traveler's group at Oak Ridge National Laboratory (ORNL). Also, from discussions at all three locations, information in areas directly relevant to DOE programs at ORNL was obtained.

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University of Tokyo

The traveler conducted collaborative research with Professors Y. Yamazaki and K. Komaki. These colleagues are highly regarded experimental physicists who work on various phenomena in the general area of dynamic interactions of swift particles with condensed matter.

The traveler was particularly interested in seeing the data that Professors Yamazaki and Komaki had recently collected in their attempt to determine whether passage of antiprotons through a solid can generate "wake-riding" electrons. The latter are electrons captured and carried along by the electron-density wake that forms behind the antiproton as it speeds through the solid. Wake-riding electrons were suggested by Dr. R. H. Ritchie of ORNL and have been the object of considerable theoretical study by him and others, but the occurrence of such electrons has never been demonstrated experimentally despite wide-spread interest in the concept. The secondary-electron energy distribution measured in this experiment appears to contain a peak that may be evidence for wake-riding electrons, but the statistical fluctuations in the data are too large to permit a definite conclusion. These workers are applying for accelerator time to repeat the experiment with longer counting times. If the preliminary result is confirmed, renewed interest in this phenomenon will be stimulated at ORNL and elsewhere.

During this visit, calculations were performed on the number distribution of secondary electrons produced by passage of swift protons through carbon foils for the purpose of comparison with experimental results previously obtained by Professor Yamazaki. Dr. R. H. Ritchie and the traveler previously collaborated with Professors Yamazaki and Komaki on the development of a theoretical model for the process and of a computer program based on the model. This computer program has subsequently been somewhat refined by Professor Komaki.

The traveler discussed his recent theoretical results on the forces experienced by high-velocity ions in anisotropic materials such as oriented graphite. The theory predicts a directional dependence of the energy loss of such ions and also a deflection of an ion beam if it is not directed along a principal optical axis of the medium. Professors Komaki and Yamazaki plan to test the theory experimentally if the traveler's calculations currently in progress predict a deflection angle of more than a milliradian for a proton beam in a graphite foil.

Symposium on Dynamic Particle-Condensed Matter Interactions

At the symposium, the traveler gave an invited talk on the stopping power of crystals. This covered his results on directional dependence and his prior work on channeled stopping power. This symposium provided a valuable opportunity to sit down with Dr. H. Nitta of Tokyo Gakugei University and discuss the differences between the traveler's theory and that of Dr. Nitta's concerning

channeled stopping power. Although the two are alike in most respects, the older theory (by the traveler) agrees with the experiment more closely than does the newer one.

Of special interest was the report by Professor N. Stolterfoht (Hahn-Meitner Institute, Berlin) of his very recent high-precision measurements of the velocity distribution of secondary electrons generated by passage of high-velocity, high-Z ions through a foil. In previous measurements at lower resolution, such distributions were found to contain a maximum (a cusp) at an electron velocity equal to the ion velocity. However, the latest (high-resolution) result is that the cusp appears at a velocity slightly higher than that of the ion. A plausible explanation suggested by us, and elaborated by Professor P. Echenique of San Sebastian, Spain, is that the cusp is formed inside the solid, and the electrons in it are accelerated upon crossing into the vacuum by the image charge from the ion. Such images, and dynamic effects of them, are an important theme of the research of Dr. Ritchie and collaborators (including Professor Echenique), and this newly-observed shift of the cusp may provide an interesting test of theory developed here.

Osaka University

The traveler visited the Institute of Scientific and Industrial Research at Osaka University at the invitation of Professor F. Fujimoto. Although Professor Fujimoto has just been at Osaka since April of this year, he has a group organized, with several experimental projects under way. Of particular interest to the traveler is a recent attempt to observe (for the first time) X-ray emission from channeled ions that have undergone resonant coherent excitation in a crystal. Because of a low signal-to-noise ratio, the data barely demonstrate the occurrence of the emission in question, but Professor Fujimoto plans to repeat the experiment at ORNL next year in collaboration with members of the Physics Division. It is possible that such measurements will yield interesting information concerning the atomic physics of channeled ions.

The traveler also visited Professor K. Shimizu and coworkers in the Department of Applied Physics. A good portion of the work of this well-equipped group revolves around a variety of electron microscopes. The traveler was shown a scanning transmission microscope (STEM) that has a lateral resolution of 1.8 A, said to be the best resolution of any STEM in existence. Of most interest is the work on electron-stimulated desorption from well-characterized surfaces under ultrahigh vacuum conditions and on measurements of the surface plasmon in aluminum-magnesium alloys whose compositions vary rapidly with distance from the surface.

SUMMARY

The traveler worked with Professors Y. Yamazaki and K. Komaki of the University of Tokyo on problems connected with the penetration phenomena of accelerated ions with solids. The traveler also discussed recent results with Professors F. Fujimoto and R. Shimizu

and members of their research groups at Osaka University. These colleagues are all doing important experimental work on interactions of charged particles in solids, with emphasis on mechanisms of dynamic processes. Discussions and collaboration between them and the traveler are quite beneficial to DOE programs at ORNL. The traveler participated in the Symposium on Dynamic Particle-Condensed Matter Interactions at Hakone, presenting a paper on his research. Much information of importance to DOE programs at ORNL was obtained.

APPENDIX

Persons contacted

Many people were contacted during this trip. The most important contacts were with Professor Y. Yamazaki (University of Tokyo), Professor K. Komaki (University of Tokyo), Professor N. Stolterfoht (Hahn-Meitner Institute, Berlin), Dr. H. Nitta (Tokyo Gakugei University), Professor R. Shimizu (Osaka University), and Professor F. Fujimoto (Osaka University).

Itinerary

11/28-29/88	Travel from Oak Ridge, Tennessee, to Tokyo, Japan
11/30-12/2/88	Collaborative research at the College of Arts and Sciences, University of Tokyo, Tokyo, Japan
12/3/88	Weekend
12/4-5/88	Symposium on Dynamic Particle-Condensed Matter Interactions, Hakone, Japan
12/6-8/88	Institute of Scientific and Industrial Research, Osaka University, Osaka, Japan
12/9/88	Travel from Tokyo, Japan, to Oak Ridge, Tennessee

Literature Acquired

F. Fujimoto et al, "Photon Emission from Resonant Coherently Excited Heavy Ions," *Nucl. Instr. and Meth.* B 33, 354 (1988).

Y. Iwata et al, "Detection of Hydrogen Adsorbed on Tungsten Surfaces Using the $^{1}H(^{15}N, \alpha\gamma)^{12}C$ Reaction," *Nucl. Instr. and Meth.* B 33, 574 (1988).

K. Komaki, F. Fujimoto, and Y. Kamiya, "Radiation from Axially Channeled 1-MeV Electrons in Germanium," *Nucl. Instr. and Meth.* B 33, 26 (1988).

S. Namiki, H. Nitta, and Y. H. Ohtsuki, "Quantum Theory of Local Stopping Power for Fast Channeled Ions," *Phys. Rev.* B 37, 1448 (1988).

H. Nitta, S. Namiki, and Y. H. Ohtsuki, "Comparison Between Quantum and Classical Diffusion Functions for Channeled Particles," *Phys. Lett.* A 128, 501 (1988).

H. Nitta and Y. H. Ohtsuki, "Dechanneling and Stopping Power of Relativistic Channeled Particles," *Phys. Rev.* B 38, 4404.

H. Nitta and Y. H. Ohtsuki, "Secondary Electron Emission by Channeled Positrons and Electrons," (preprint).

A. Ootuka et al, "Molecular Effects in KL^{n} Multiple Ionization of Al for H^{+} and H_2^{+} Ion Impacts," *Nucl. Instr. Meth.* B 33, 304 (1988).