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FOREIGN TRIP REPORT

FTR-3761

DATE: October 1, 1990

SUBJECT: Report of Foreign Travel of Yok Chen, Senior Research Staff Member,
Ceramics and Interfaces Section, Solid State Division, ORNL

TO: A. W. Trivelpiece

FROM: Yok Chen

PURPOSE: To chair a session and present two papers at the Sixth Europhysical Topical Conference on Lattice Defects in Ionic Materials, Groningen, the Netherlands; to visit the University of Paris, Paris, France; to visit the University of Zaragoza, Zaragoza, Spain; the University of Madrid Complutense and the Junta de Energia Nuclear (Nuclear Energy Commission), Madrid, Spain, for collaborative purposes.

SITES VISITED:	9/3-7/90	Europhysical Conference, Groningen, the Netherlands	
	9/10-11/90	The University of Paris, Paris, France	P. Lavallard C. Julien
	9/11-13/90	The University of Zaragoza, Zaragoza, Spain	V. M. Orera
	9/14/90	Junta de Energia Nuclear, Madrid, Spain	E. Hodgson
	9/14-15/90	The University of Madrid, Madrid, Spain	C. Ballesteros R. Gonzalez

ABSTRACT: The traveler chaired a session at the Sixth Europhysical Conference on Lattice Defects in Ionic Materials and coauthored two contributed poster papers entitled, "Intrinsic Defects in Stabilized Zirconia Produced by Thermochemical Reduction or Irradiation" and "The [H-Ca⁺] Defect in Thermochemically Reduced CaO: Static and Dynamical EPR Study." He visited the University of Paris, the University of Zaragoza, the University of Madrid Complutense, and the Junta de Energia Nuclear.

I. INTRODUCTION

The traveler's trip to Europe consisted of attendance at (or visit to): (1) the Sixth Europhysical Topical Conference on Lattice Defects in Ionic Materials in Groningen, the Netherlands; (2) the University of Paris, Paris, France; (3) the University of Zaragoza, Zaragoza, Spain; and (4) the University of Madrid Complutense and the Junta de Energia Nuclear, Madrid, Spain.

II. THE SIXTH EUROPHYSICAL TOPICAL CONFERENCE ON LATTICE DEFECTS IN IONIC MATERIALS

The chairman of the conference was W. H. den Hartog of the University of Groningen. This series of conferences, abbreviated LATDIM, is the European version of the International Conference on Defects in Insulating Crystals (ICDIC), last held in Palma, Italy, in 1988 and draws participants from essentially the same segment of the solid state science community. The participants at the conference numbered about 200, which is about 75 less than at typical LATDIM and ICDIC conferences. Generally, a large contingent of students from the host country attend these meetings; however, I did not see many students at this meeting, which accounts for the diminished participation. Traditionally, the LATDIM series have been strongly oriented toward transport phenomena in the alkali halides. In the past, there has been good balance among different materials, (e.g., glasses, alkali halides, perovskites, quartz, sapphire, LiNbO_3 , KNbO_3 , ZrO_2 , magnesium lanthanum aluminate, and the alkaline-earth oxides). The topics covered were varied: nonlinear optics, spectroscopy (optical, magnetic resonance, and dielectric), optically detected magnetic resonance, diffusion, solid electrolytes, dynamic processes, hole burning, Raman scattering, and time-resolved spectroscopy.

Since I am presently on assignment from ORNL to the Department of Energy (DOE), Division of Materials Sciences, Washington, D. C., I attended the meeting as a representative of DOE. In this capacity, my main role was to observe whether there are important new sciences on the horizon and whether these fall within the

purview of this office. I was also a coauthor of two poster papers, presented as a member of the Solid State Division, ORNL, and chaired a session. The titles of the two papers were "Intrinsic Defects in Stabilized Zirconia Produced by Thermochemical Reduction or Irradiation" and "The [H-Ca⁺] Defect in Thermochemically Reduced CaO: Static and Dynamical EPR Study."

It was my observation that the paper which had the most impact technologically was presented in the session which I chaired. The paper was read by E. R. Hodgson of the Junta de Energia Nuclear, Madrid, Spain, and the sponsor of the work was EUATOM/CIEMAT Fusion Association. Hodgson observed radiation-induced electrical breakdown at moderate temperatures and doses in Al₂O₃ (sapphire). A series of experiments were performed with 2.0-MeV electrons from a van de Graaff generator. This result poses a serious problem for both near-term and future reactor devices in which the use of electrical insulators surrounding toroidal coils will be extensive. Our own work several years ago showed that: (1) even under much higher temperatures and electric field, Al₂O₃ did not experience dielectric breakdown and (2) irradiation of this material with energetic electrons to very high doses did not produce significant radiation damage even at room temperature. Thus, the selection of this compound as an insulating material for fusion devices is well-founded. The importance of Hodgson's work is that the combination of temperature, electric field, and radiation has a devastating effect on what was believed to be the best insulating material for this technology.

Even though the result is new, the impact has already infiltrated into the fusion community. The New European Torus (NET) is now being redesigned. Experiments at Harwell using electrons have already duplicated Hodgson's results. The Japanese are performing the same experiment with neutrons instead of electrons. The preliminary result appears to be that there are experimental problems associated with the measurements. At this point there appears to be no viable replacement candidates for sapphire. The course of action is to increase the separation threefold between the neutral injection beam and the NET. Hodgson, heretofore relatively unknown in the field of ceramics, has made his imprint in an important technological area. He has already received an invitation to visit Japan. I might add that although we have been helpful to him in his scientific

endeavor in the past four years, I was not aware that he was working in this area until recently.

Also attending the meeting were some of my present collaborators and former collaborators: Max Glasbeek of the University of Amsterdam; J. L. Bóldú of the Universidad Nacional Autonoma de Mexico (UNAM); B. Henderson of the University of Strathclyde, Glasgow, Scotland; and V. M. Orera of the University of Zaragoza, Zaragoza, Spain. Glasbeek and I are currently collaborating on several ceramic materials. Bóldú, who did his Ph.D. thesis with Marvin Abraham and me at ORNL, is now the Dean of the School of Sciences at UNAM, perhaps the largest university in the world. He has recently initiated a memorandum of understanding between his university and ORNL on an exchange program. Henderson is an administrator overseeing a program on photonic materials and has a chair in his university. Orera gave an invited talk at the meeting.

III. THE UNIVERSITY OF PARIS, PARIS, FRANCE

V. M. Orera, my collaborator for eleven years, and I visited both the University of Paris-VII (l'Ecole Normale Supérieure) and the University of Paris-VI (Pierre and Marie Curie University). The solid state physics groups from both universities are conveniently housed in the same building, so it was quite easy to go from one group to the other. My impression is that both universities are well-equipped, and the scientists are very knowledgeable about their fields.

Our visit to the University of Paris-VII was hosted by P. Lavallard. We also met his postdoctoral student, C. Gourdon, who has been quite productive. They have been working primarily on two materials: (1) $\text{CdS}_{1-x}\text{S}_x$ alloys and (2) GaAs/AlAs superlattices. In the $\text{CdS}_{1-x}\text{S}_x$ alloys, they used picosecond time-resolved luminescence to investigate excitons localized by alloy potential fluctuations. In order to discriminate between excitons localized on S clusters, free excitons, or impurity-bound excitons in Se-rich $\text{CdS}_{1-x}\text{S}_x$ alloys, they used photoluminescence spectra of the alloy and compared them with the spectra of pure CdSe. They were able to show that two main peaks were due to free and donor-bound exciton recombination. They also studied the photoluminescence

and excitation spectra of several GaAs/AlAs short-period superlattices (SPSL) using linearly polarized resonant excitation. They found that the luminescence has a large degree of polarization, which they attribute to hidden anisotropy of localized exciton states. This anisotropy likely results from the microscopic properties of the monolayer-thick growth steps in the SPSL.

Our visit to the University of Paris-VI was hosted by C. Julien. He impressed me as a very clever scientist, but he does not publish much. He is mainly concerned with fast-ionic conductors. His current interests are (1) the ionic conductivity of the lithio-borate glass system and the analysis of the fast ionic transport in these solid electrolytes and (2) infrared reflectivity spectroscopy to determine the dynamical properties of Li^+ ions in $\text{B}_2\text{O}_3\text{-xLi}_2\text{O-yLi}_2\text{SO}_4$ glasses. In the latter, he uses the reflectivity dependence on frequency to deduce ionic conductivity and the motion of Li^+ ions. Basically the infrared spectra of $\text{B}_2\text{O}_3\text{-xLi}_2\text{O-yLi}_2\text{O}_4$ glasses can be regarded as consisting of two parts: the low-frequency side which concerned the charge-carrier dynamics and the higher frequency region which concerns the host dynamics.

IV. VISIT TO THE UNIVERSITY OF ZARAGOZA, ZARAGOZA, SPAIN

My host was V. M. Orera. We first met in 1979, when he came to ORNL on a Spanish grant to work with me, soon after he completed his Ph.D. thesis at Harwell. He returned to work at ORNL in 1985 and 1987 to help me with my DARPA-funded project on tunable lasers. Early this year he was promoted to the rank of a full professor, which in Europe is quite an accomplishment, especially for someone who is 39 years old. His laboratory is very impressive and includes a crystal growth facility, optical absorption spectrophotometers, photoluminescence and time-resolved spectroscopy, electron paramagnetic resonance (4.2 to 600 K), electron nuclear double resonance (up to 100 MHz), Raman spectroscopy (380- to 840-nm excitation and OMA detection). He has recently ordered a $\$1 \times 10^6$ Bruker Fourier transform, nanosecond microwave-pulsed EPR-ENDOR spectrometer with spin-echo, variable frequency, and 3D plotting to study dynamical processes

and possibly biological materials. Also, on order is a facility for dielectric spectroscopy. He claims his laboratory will be the best in Europe.

Our collaboration has been very active. In the past seven months we have submitted three papers to *Physical Review*; all three have been accepted. We are currently working on Y-stabilized ZrO_2 and ZnO .

V. THE UNIVERSITY OF MADRID COMPLUTENSE AND THE JUNTA DE ENERGIA NUCLEAR, MADRID, SPAIN

My hostess and host at the university were C. Ballesteros and R. Gonzalez, respectively. I first met Gonzalez in 1981, when he came to work with me at ORNL on a Spanish government grant. Both Ballesteros and Gonzalez came to Oak Ridge in 1986-1988 to help me work on the DARPA-funded project on tunable lasers. Our collaboration has also been very active and fruitful.

My host at the Junta de Energia Nuclear was E. R. Hodgson. The purpose of the visit was twofold: to work on a manuscript on LiNbO_3 and to obtain more information on his important discovery of radiation-induced dielectric breakdown in sapphire. He graciously provided me preprints and other information.

VI. GENERAL COMMENTS

This trip was scientifically very stimulating and rewarding for me. The quality of the papers presented at the conference was very high. Equally important, it gave me an opportunity to further interact with foreign colleagues, especially those with whom I am collaborating. It was delightful to see that my collaborators' laboratories have developed into world-class facilities. It is my opinion that participation by U. S. scientists in international conferences of this type is essential and should be encouraged. Such meetings permit scientists not only the opportunity to keep themselves abreast of research throughout the world but also provide a forum to interact with foreign scientists and to publicize their research.

APPENDICES

A. ITINERARY

B. LITERATURE ACQUIRED DURING FOREIGN TRAVEL

APPENDIX A

ITINERARY

DATES	LOCATION	INDIVIDUALS CONTACTED	SUBJECT OF DISCUSSION
<u>1990</u>			
9/1-2	Travel from Washington, DC, to Groningen, the Netherlands, via plane		
9/3-7	Sixth Europhysical Topical Conference on Lattice Defects in Ionic Materials, Groningen, the Netherlands	W. H. den Hartog	Presentation of two poster papers and chair session at conference.
9/8-9	Travel en route from Groningen, the Netherlands, to Paris, France		
9/10-11	University of Paris, Paris, France	P. Lavallard C. Julien	Electrical and optical properties of ionic conductors.
9/11-13	University of Zaragoza, Zaragoza, Spain	V. M. Orera	Electrical and optical properties of oxide crystals.
9/14	Junta de Energia Nuclear, Madrid, Spain	E. R. Hodgson	Discussions on radiation-induced dielectric breakdown in sapphire.
9/14-15	University of Madrid, Madrid, Spain	C. Ballesteros R. Gonzalez	Electrical and optical properties of oxide crystals.
9/16	Travel en route from Madrid, Spain, to Washington, DC, via plane		

APPENDIX B

LITERATURE ACQUIRED DURING FOREIGN TRAVEL

1. C. Gourdon and P. Lavallard, "Exciton Transfer Between Localized States in $\text{CdS}_{1-x}\text{S}_x$ Alloy," *Phys. Status Solidi b* **153**, 641 (1989).
2. C. Gourdon, P. Lavallard, S. Permogorov, and A. Reznitsky, "Evidence for Persistence of Free and Impurity-Bound Excitons in Se-Rich $\text{CdS}_{1-x}\text{S}_x$ Alloys," *J. Lumin.* **39**, 260 (1988).
3. C. Gourdon, P. Lavallard, S. Permogorov, A. Reznitsky, Y. Aaviksoo, and Y. Lippmaa, "Picosecond Time-Resolved Luminescence of Localized Excitons in $\text{CdS}_{1-x}\text{S}_x$," *J. Lumin.* **39**, 111 (1988).
4. S. Permogorov, A. Naumov, C. Gourdon, and P. Lavallard, "Hidden Anisotropy of Localized Exciton States in Short Period GaAs/AlAs Superlattices," *Solid State Commun.* **74**, 1057 (1990).
5. M. Balkanski, I. Darianian, P. A. Burret, M. Massot, and C. Julien, "Dynamical Properties of Lithium in Borate Glasses $\text{B}_2\text{O}_3-x\text{Li}_2\text{O}-y\text{Li}_2\text{SO}_4$ Deduced from IR Spectroscopy," *Mater. Sci. and Eng.* **B3**, 177 (1989).
6. C. Julien and M. Massot, "Complex Impedance Spectroscopy," to appear in Ch. 3.5 in *Microionics: Solid State Integrable Batteries*, ed. by M. Balkanski, Elsevier, Oxford, 1990.
7. P. J. Alonso, R. Alcala, J. Casas-Gonzalez, R. Cases, and V. M. Orera, "Spectroscopy of Chromium (III) in Yttrium-Stabilized ZrO_2 ," *J. Phys. and Chem. Solids* **50**, 1185 (1989).
8. V. M. Orera, M. L. Sanjuan, R. Alcala, J. Fontcuberta, and S. Pinol, "Raman Study of Superconducting $\text{Nd}_{2-x}\text{Ce}_x\text{CuO}_{4-y}$ Single Crystals," *Physica C* **168**, 161 (1990).
9. M. L. Sanjuan and V. M. Orera, "The Saturation Behavior of the EPR Lines of the Motional Defect $\text{H}_i^\circ(\text{Li})$ in MgO ," *J. Phys. C: Solid State Phys.* **21**, 2941 (1988).
10. V. M. Orera, P. J. Alonso, M. L. Sanjuan, and R. Alcala, " $\text{H}_i^\circ(\text{Li})$ and $\text{D}_i^\circ(\text{Li})$ Defects in CaO Studied by EPR: Reorientational and Vibrational Features," *Phys. Rev. B* **39**, 7928 (1989).

COVER SHEET
FOR TRIP REPORTS SUBMITTED TO THE
OFFICE OF ENERGY RESEARCH

Destination(s) and Dates for
Which Trip Report Being Submitted: the Netherlands, France, and Spain (9/3-14/90)

Name of Traveler: Yok Chen

Joint Trip Report ☐ Yes
☒ No

If so, Name of Other Traveler(s): _____

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