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FOREIGN TRIP REPORT

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DATE: January 3, 1989

SUBJECT: Report of Foreign Travel of Paul F. Becher, Group Leader,
Structural Ceramics Group, Metals and Ceramics Division

TO: A. Zucker

FROM: P. F. Becher

PURPOSE: The purpose of this trip was to present an invited plenary lecture at and attend the 7th International Conference on Ceramics, Bologna, Italy. Participation in the conference afforded the traveler the opportunity to learn about and discuss current research activities, especially those in Europe in composites, electronic ceramics, ceramic processing, superconducting ceramics, and structural ceramics. The traveler also participated in the Conference planning meeting as a member of the International Advisory Committee.

SITES

VISITED: 12/14-17/88 7th International Conference C. Palmonari
on Ceramics, Palazzo dei
Congressi, Bologna, Italy

ABSTRACT: The 7th International Conference on Ceramics addressed current research in the fields of ceramic composites, electronic and superconducting ceramics, and ceramic processing. Technical papers by researchers from western and eastern Europe, Asia (including Japan and China), Australia, and the United States were presented. The traveler presented an invited lecture on the analysis of the toughening behavior in whisker reinforced ceramics and their mechanical properties.

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COMPREHENSIVE TRIP REPORT

The 7th International Conference on Ceramics covered a very wide range of topics over a four-day period. Highlights of the meeting from the traveler's viewpoint are described below. In the session on superconducting ceramics, the invited lecture by Dr. D. Clarke of IBM Research Laboratory summarized our understanding of the 1-2-3 YBaCuO compound in terms of phase equilibria and processing effects on current density capacity. Thin film results show that the critical current density decreases with increase in grain misorientation and grain size. Because of the crystallographic thermal expansion anisotropy, this can be related to microcracking due to an increase in stress intensity arising from residual stresses at grain boundaries. An interesting point of the report by Dr. J. Routort of Argonne National Laboratory was the anisotropy in the oxygen diffusion in superconducting ceramics.

The invited lectures in the session on composites by Prof. A. Evans of University of California and the traveler dealt with the toughening behavior of continuous fiber and whisker reinforced ceramics, respectively. Papers by Drs. Ai-Kang Li of IIT Research Center-Taiwan and J. P. Singh of Argonne National Laboratory described results for whisker reinforced ceramics that indicated the loss in toughness due to certain thermal treatments was a result of a decrease in the whisker strength to whisker-matrix interface strength ratio. Dr. A. Solomah of the Institut für Chemische Technologie-Jülich discussed the improvement of the thermal shock resistance of alumina by the addition of both zirconia particles and SiC whiskers. Later the traveler discussed with Dr. Solomah the questions of toughening mechanisms and techniques used to measure toughness. Tentative plans were made for Dr. Solomah to visit the traveler to follow up on these discussions. The paper presented by Dr. L. Baum of the Israel Institute of Technology provided some interesting technical insight into the processing and properties of ceramic composites formed by controlled oxidation of aluminum alloys which had been infiltrated into a ceramic particle preform. For the formation of SiC-alumina composites, the silicon content of the aluminum alloy must be above a critical level to prevent reactions between SiC and the molten alloy. The magnesium additions to the alloy appear to influence the rate of propagation of the oxidation front.

The next session dealt primarily with the response of ceramics in corrosive and/or high temperature environments and in the presence of moving contact stresses. Two papers were most interesting. Dr. G. Ondracek of the Institut für Gesteinshuttenkunde at Aachen addressed the relationships between thermal and mechanical properties and the microstructure of composites. As he noted, the introduction of debonding of the interface between a particular matrix and the reinforcing/second phase will influence thermal expansion behavior but not necessarily the elastic properties. In fact, studies on alumina-SiC whisker composites by the traveler and his colleagues and Dr. Ondracek's work show that one could detect the initiation of interface debonding in this manner. Prof. R. Scattergood of North Carolina State University

described some very interesting experimental work which show R-curve (i.e., increasing fracture toughness with increase in crack length) could be used to account for material removal rates and the extent of damage during the machining of ceramics, especially composites, larger-grain-sized aluminas, and transformation toughened ceramics.

In the session on zirconia ceramics there were several points of interest. First, there appears to be a lack of concern on the part of researchers involved in the processing and development of improved zirconia ceramics with the use of accurate techniques to measure fracture toughness. For the most part, techniques are used that do not account for either residual stress or R-curve effects. As a result, one cannot compare results for differences in processing or composition on toughness achieved at either a given facility or amongst different researchers. Prof. Sato of Tohoku University described how improving the density of ceria-doped polycrystalline tetragonal zirconia (Ce-TZP) containing 20 vol % alumina particles enhanced fracture strength and toughness. This was achieved by use of a unique hot isostatic pressing unit (Kobe Steel) which can employ an oxygen-argon environment (note that in Ce-TZP an oxygen environment is required to prevent severe reduction reactions). Dr. Piriou of CNRS-Meudon discussed his work on site selective spectroscopy to study the tetragonal to monoclinic (t to m) transformation in both "pure" and yttria-doped TZP ceramics using small (<0.1 mol %) europia additions. Most interesting was his observation that the temperature for the onset of both the t to m (M_s) and the m to t (A_s) transformation lay between 77 K and 300 K in 0.5 mol % yttria-doped TZP. In the pure zirconia, he indicated M_s lay between 77 K and 300 K and A_s was >300 K. Prof. Norby of the University of Oslo showed that the t to m and the reverse transformation in pure zirconia were not influenced by the relative humidity of the air environment. Mr. Wang of the University of Leeds showed how the fracture strength and toughness of Y-TZP ceramics could be improved by increasing grain size. These results, however, likely reflect increases in cubic phase content during heat treatment which would decrease the yttria content of the remaining tetragonal phase. Thus one could not unambiguously separate grain size and compositional effects in these studies.

Private discussions were held with Prof. S. Meriani of the Universite of Trieste on the t to m transformation in zirconia ceramics. Prof. Meriani's group has a large effort in zirconia ceramics and is interested in the phase transitions. During the discussions, Prof. Meriani indicated his interest in conducting high temperature X-ray diffraction studies. The traveler recommended that he contact personnel in the HTML User Facilities at Oak Ridge National Laboratory about the possibility of utilizing their system.

In addition to the oral presentations, there were also poster sessions on advanced ceramics and zirconia ceramics. However, there was little opportunity to discuss the posters with the authors. The traveler requested preprints of several of these papers. The conference provided an overview of ceramics research activities in Europe, especially Italy, on topics which could have been the sole topic of a conference.

APPENDIX A

Itinerary

12/12-13/88	Travel to Bologna, Italy
12/14-17/88	7th International Conference on Ceramics, Bologna, Italy
12/18/88	Travel from Bologna, Italy, to Oak Ridge, Tennessee

APPENDIX B

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