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JAN 77 G. Y ONODA, L L HENCH

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THE SCIENCE OF CERAMIC PROCESSING BEFORE FIRING
Tenth Annual University Conference on Ceramic Science

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FINAL REPORT

George Y. Onoda, Jr.
and
Larry L. Hench

January 24, 1977

U. S. ARMY RESEARCH OFFICE

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1 October 1974-30 June 1975

University of Florida
Department of Material Science and Engineering
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report summarizes the outcome of the tenth annual University Conference on Ceramic Science. The subject was "The Science of Ceramic Processing Before Firing." The highlights of the conference papers are summarized and a list of participants is provided.		

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I. INTRODUCTION

In this final report, a summary of the conference papers is provided. Also enclosed is the final program and a list of registrants.

During the Xth University Conference on Ceramic Science the scientific level of both theoretical and application papers on the theme "Science of Ceramic Processing Before Firing" reached a previously unparalleled stature. The Conference took place January 27-30 at the University of Florida, Gainesville. The level of technical excellence provided a fitting recognition of the conference keynoters Karl Schwartzwalder and Frederick H. Norton, who were honored during the meeting for their pioneering contributions to the science and technology of ceramic processing. Commissioned ceramic vases by Philip Ward were accepted on behalf of the honorees by Ralston Russell, Jr. and Joseph E. Burke, president-elect and president of the Society, respectively.

II. SUMMARY OF CONFERENCE ACTIVITIES

For perhaps the first time ever, a series of papers tackled the difficult questions of how to prepare powders with a controlled high activity, how to achieve quantitative characterization of active and nonactive powders, and how to control the fabrication of active powders into bodies. It was shown that the answers to these questions center around the behavior of agglomerates.

Papers on grinding (Somasundarun; Berg) and solution precipitation of powders (Johnson and Gallagher; Harada and Gates;

Flock) demonstrated that improvements in powder preparation usually are associated with altering the size and compactness of agglomerates. Size, strength and stability of alumina agglomerates and other powdered agglomerates were described in great detail in various papers (Flock; Page, Metzbower, Shanefield and Hasselman; Hench and Jenkins; Niesz; Tremper and Gordon; Rumpf; Orr; Pincus; DeHoff and Whitney). By applying the wide range of analytical tools described in these papers a thorough characterization of agglomerate features can be achieved and followed throughout various processing steps.

The influences of mixing, binders, powder packing, compaction and drying on rearrangement of agglomerates and green body character were described with quantitative detail by a number of authors (Fuerstenau; Onoda; Rhines; Whittemore; Cooper). Ceramic systems that involve extensive liquid-particulate interactions were also covered in a systematic manner. Surface chemistry, rheology, mixing, extrusion and drying oxide and clay systems were analyzed (Lawrence; Fuerstenau; Sommer and Rumpf; Phelps and McLaren; Williamson; Heystek; Robinson; Farris; Verma).

The importance of powder and prefire processing variables on the firing behavior of ceramics is all too often a neglected topic. However, several papers (Cutler; Kingery; Palmour and Hare; Pope, Morton, Hall and DiVita) served to emphasize that without powder processing control, improvements in reliability, yield and performance of ceramics by altering firing steps are highly unlikely.

Production of electronic substrates by tape casting of alumina requires optimal control of each processing step. R. E. Mistler revealed a detailed description of the processing steps and controls developed in the Western Electric Co. tape casting operation, providing a special highlight of the Conference. Another highlight was the panel discussion of potential future developments in ceramic processing involving Joseph A. Pask, Joseph E. Burke, Ralston Russell, Jr., D. W. Fuerstenau, Richard A. Alliegro and William B. Crandall. It was predicted from this discussion that a shift in industrial, university and government research emphasis from physical ceramics to processing science will continue to gain momentum in the decade ahead.

III. ATTENDANCE

The conference was well attended, with over 200 participating, including students from the University of Florida and other schools throughout the country. A list of registrants is provided in Appendix I. An important statistic is that over 100 industrial firms were represented.

IV. PUBLISHED PROCEEDINGS

Thirty-five of the papers presented at the conference were submitted in manuscript form. Because of the absence of an adequate textbook on the science of ceramic processing, it was felt that the proceedings of this conference should be extensively edited to a text-book format, and published as a type-set text.

Wiley-Interscience, John Wiley and Sons, Inc., has accepted the manuscript as a textbook and the book is now being processed and should be in print in the summer of 1977. The number of books requested by the Army Research Office will be sent when the book is published.

Final Program

tenth university conference on ceramic science

Science of Ceramic Processing Before Firing

January 27-30, 1975



University of Florida Gainesville, Florida

REGISTRATION

The registration fee is \$95.00 per person. This fee includes one copy of the proceedings and one banquet ticket. Individuals are urged to register as far in advance as possible because registration will be limited to 300 persons and room accommodations in the Hilton are limited to 150 persons.

LOCATION OF MEETINGS

The Monday session will be held in the auditorium of the J. Wayne Reitz Student Union on the campus of the University of Florida. The sessions on Tuesday, Wednesday and Thursday will be held in the ballroom of the Gainesville Hilton.

ACCOMMODATIONS

A block of rooms is being held at the Gainesville Hilton and at the Flagler Inn for this conference. Accommodations are also available at reasonable rates at motels in the vicinity. Room reservation information will be sent to all conference pre-registrants. A banquet (paid for in the registration fee) will be held on Tuesday evening at 8:00 PM with entertainment. A cocktail hour at 7:00 will precede the banquet.

HEADQUARTERS

An official registration and information desk will be at the Gainesville, Hilton. The desk will be open on Sunday evening (5:00 to 10:00 PM) and during the day on Monday through Thursday (7:00 AM - 5:00 PM).

LADIES EVENTS

Trips will be arranged to Silver Springs and to Saint Augustine, Florida. Individual banquet and luncheon tickets may be purchased. Bridge parties and other accommodations are planned in the Gainesville Hilton.

FOR ADDITIONAL INFORMATION

Write or Telephone G. Y. Onoda, Conference Chairman or L. L. Hench, Co-Chairman, (904) 392-1497.

9:45-10:05 "Powder Compaction," O. J. Whittemore, Jr. (University of Washington)
10:15-10:40 "Origin of Pressing Flaws," R. Carter, R. A. Thompson, R. S. Coblentz and R. A. Rand (General Electric Co.)
10:50-11:20 "Green Body Defects," L. E. Ferreira (Interpace Corp.)
11:30-12:00 "Strength and Microstructure of Dried Clay Mixtures," W. O. Williamson (Pennsylvania State University)

12:30-1:30 Lunch

2:00-2:30 "Body Defects from Organic Binders," G. Y. Onoda, Jr. (University of Florida)

PANEL DISCUSSION ON PROCESSING RESEARCH
2:30-4:00 Moderator—J. A. Pask (University of California)

Panel members—R. Russell, Jr. (Ohio State University), D. W. Fuerstenau (University of California), J. E. Burke (General Electric Co.), L. E. Ferreira (Interpace Corp.), R. A. Alleigro (Norton Co.), W. B. Crandall (Alfred University)

Honoring....

Karl Schwartzwalder
and
Frederick H. Norton

for their pioneering contributions
to the science and technology of
ceramic processing.

Sponsored by

U.S. Army Research Office—Durham, N.C.
U.S. Bureau of Mines—Washington, D.C.
Department of Materials Science and
Engineering, University of Florida

This public document was promulgated at a cost of \$0.07 per copy or \$625.60 to inform interested persons of the program of the Ceramic Science Conference.

PROGRAM

MONDAY, JANUARY 27, 1975

WELCOME AND OPENING REMARKS

- 8:30-8:45** University of Florida staff
- KEYNOTE ADDRESS**
- 8:50-9:00** Presentation of Keynote Honoree by R. Russell, Jr. (Ohio State)
- 9:05-9:35** Keynote Address, Karl Schwartzwalder
- POWDER PREPARATION**
- 9:35-9:55** "Need for Active Powders," I.B. Cutler (University of Utah)
- 10:00-10:25** "Theories of Grinding," P. Somasundaran (Columbia University)
- 10:35-11:05** "Alumina Grinding," M. Berg (General Motors Corp.)
- 11:15-11:45** "Ceramics from Solution," D.W. Johnson, Jr. and P.K. Gallagher (Bell Laboratories)
- 11:55-12:15** "Mixed Oxalate Precipitation and Calcination," Y. Harada (IIT Research Institute) and D.W. Gates (NASA)
- 12:30-1:30** Lunch
- CHARACTERIZATION OF POWDERS**
- 2:00-2:20** "Importance of Powder Characterization," A.G. Pincus (Rutgers University)
- 2:30-3:10** "Physical Characterization of Particulates," C. Orr (Georgia Institute of Technology)
- 3:20-3:45** "Characterization of Clays," H. Heystek (Bureau of Mines)
- 3:55-4:20** "Selection and Treatment of Diamond Particulates in Preparation for High Thermal Conductivity Ceramics," B.J. Pope, M.D. Morton, and H.T. Hall (Brigham Young University and Megadiamond Corp.) and S. Di Vita (U.S. Army Electronics Command)
- 4:30-4:55** "Characterization of Powders for Thick Films and Capacitors," A. Roberts and K. Verma (Sel-rex Co.)

TUESDAY, JANUARY 28

KEYNOTE ADDRESS

- 8:30-8:40** Presentation of Keynote Honoree by J.E. Burke (General Electric Company)
- 8:45-9:15** Keynote Address, Frederick H. Norton

CHARACTERIZATION OF POWDERS—CONTINUED

- 9:25-9:55** "Reactivity and Characterization of Bayer Processed Alumina," W.M. Flock (Plessey Inc.)
- 10:05-10:35** "Lattice Strain and the Sinterability of Alumina Powders," J.P. Page (Western Electric Co.), E.A. Metzbowler (Naval Research Laboratory), D.J. Shanefield (Western Electric Co.) and D.P.H. Hasselman (Lehigh University)
- 10:45-11:05** "Transmission Electron Microscopy of Agglomerates," L.L. Hench and E.J. Jenkins (University of Florida)
- 11:15-11:45** "Agglomerate Structure and Properties," D.E. Niesz (Battelle Columbus Laboratories)
- 12:15-1:15** Lunch
- 1:45-2:05** "Characterization of Unfired Ceramics by Quantitative Microscopy," R.T. DeHoff and E.D. Whitney (University of Florida)
- 2:15-2:45** "Effect of Particle and Agglomerate Size on the Sintering of Translucent Aluminum Oxide," R.T. Tremper (General Electric) and R.S. Gordon (University of Utah)
- LIQUID-PARTICULATE SYSTEMS**
- 2:55-3:20** "Effect of Ions on the Structure of Water," W.G. Lawrence (Alfred University)
- 3:30-4:10** "Surface Chemistry of Oxide-Water Interfaces," D.W. Fuerstenau (University of California)
- 4:20-4:45** "Viscosity of Highly Concentrated Suspensions," K. Sommer (Universitat Karlsruhe, Germany)
- 4:55-5:25** "Rheology and Deflocculation of Slips," G.W. Phelps and M.G. McLaren (Rutgers University)

WEDNESDAY, JANUARY 29

LIQUID-PARTICULATE SYSTEMS—CONTINUED

- 8:30-9:00** "Mixing of Powders," D.W. Fuerstenau (University of California)
- 9:10-9:45** "Adhesion Forces in Agglomeration Processes," H. Rumpf (Universitat Karlsruhe, Germany)
- 9:55-10:30** "Properties of Organic Binder Solutions," G.Y. Onoda, Jr. (University of Florida)
- 10:40-11:10** "Mixing of Suspensions," K. Sommer and H. Rumpf (Universitat Karlsruhe, Germany)
- 11:20-11:50** "Theory of Drying Stresses," A.R. Cooper (Case Western Reserve University) Lunch
- 12:30-1:30** Lunch
- FORMING AND GREEN BODY CHARACTERIZATION**
- 2:00-2:25** "Firing-The Proof Test for Ceramic Processing," W.D. Kingery (Massachusetts Institute of Technology)
- 2:35-3:10** "Tape Casting," R.E. Mistler (Western Electric)
- 3:20-3:45** "Extrusion of Clay-Based Bodies," G.C. Robinson (Clemson University)
- 3:55-4:20** "Monolithic Approach to Refractory Construction Problems," A.W. Allen (C-E Refractories)
- 4:30-5:00** "High-Purity Refractory Concrete—The Mineralogy of Curing and Drying," R.E. Farris (Kaiser Refractories)

THURSDAY, JANUARY 30

FORMING AND GREEN BODY CHARACTERIZATION—CONTINUED

- 8:30-9:05** "Process Optimization and its Effect on Properties of Alumina Sintered Under Rate Control," T.M. Hare and H. Palmour III (North Carolina State University)
- 9:15-9:35** "Powder Packing," F.N. Rhines (University of Florida)

APPENDIX I

CONFERENCE PARTICIPANTS

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