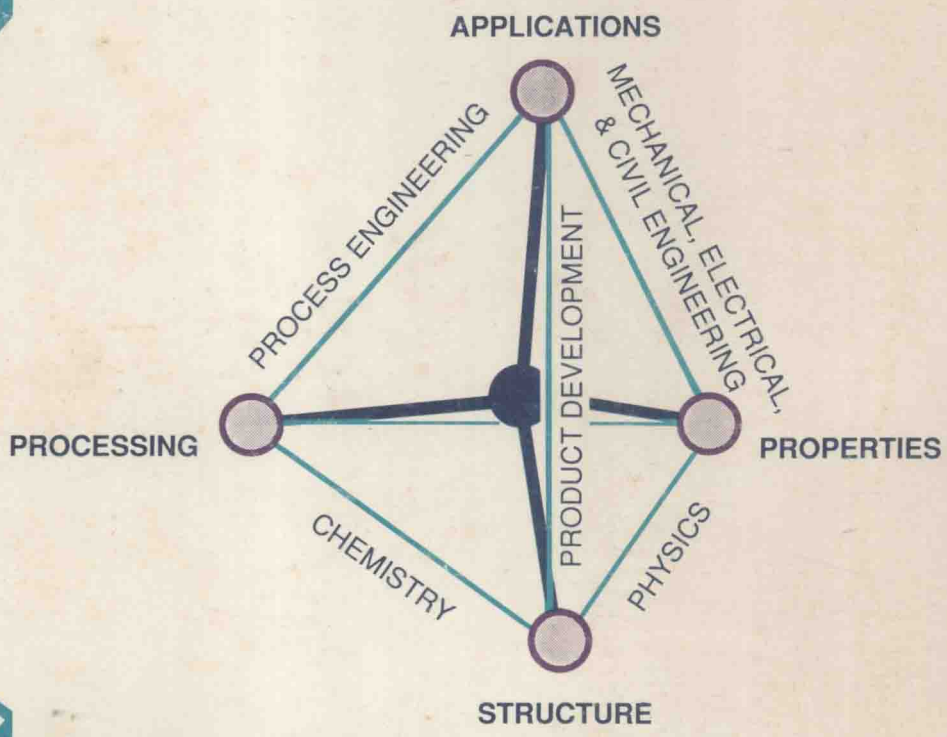
Advances in the Fusion of Glass

Proceedings of the 1st International Conference on Advances in the Fusion of Glass



Alfred University, Alfred, New York. June 14–17, 1988

Edited by

D.F. Bickford *E.N. Boulos* *F. Olix*

W.E. Horsfall *J.N. Lingscheit* *W.C. LaCourse*

F.E. Woolley *F. Harding* *L.D. Pye*

The American Ceramic Society, Inc. Westerville, Ohio

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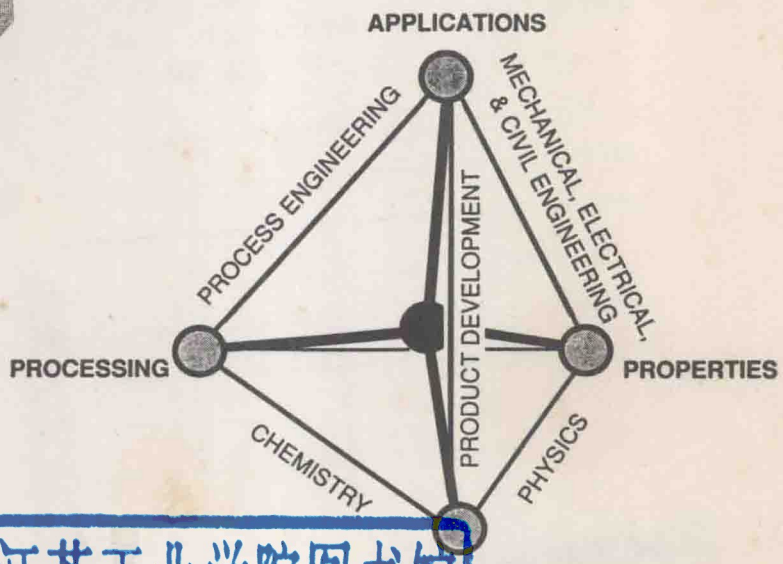

New York State College of Ceramics at
Alfred University, Alfred, New York. June 14–17, 1988

Edited by

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The organizers are grateful to all who contributed to the success of the Conference. First, we wish to thank the authors who gave so freely of their talents to ensure a quality publication. L. David Pye deserves special thanks for initiating the conference and guiding it through its conclusion. We thank the members of the International Advisory Board for their help in securing international participation.

The Conference is supported by the NSF Industry-University Center for Glass Research and the Institute of Glass Science and Engineering at the New York State College of Ceramics at Alfred University, and it is endorsed by the Glass Division of the American Ceramic Society. The senior editor wishes to thank the U.S. Department of Energy for allowing him to spend a portion of time away from his regular duties to organize the editing of these proceedings.

Local arrangements for the Conference were made by W.C. LaCourse, William Emrick, and William Earl.

Thanks go to Pam Achter of the American Ceramic Society and Carol Jantzen of the Savannah River Laboratory for their encouragement and advice. Appreciation is expressed to Pam Achter for arranging for printing and binding the proceedings. We also thank Mrs. Barbara Steed at the Savannah River Laboratory and Ms. Joyce Roberts and Regina Slingerland of the New York State College of Ceramics for retyping several of the manuscripts.

D.F. Bickford
W.E. Horsfall
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J.N. Lingscheit
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—**Editors**

PREFACE

The idea of convening a Conference at the New York State College of Ceramics at Alfred University on Advances in the Fusion of Glass originated in the summer of 1986, at about the same time as the first anniversary of the foundation of the NSF Industry-University Center for Glass Research (CGR). Prof. L. David Pye, Director of the CGR, suggested that such a conference would be a fitting way to recognize the establishment of the Center and could offer unique opportunities for interaction between glass producers, glass educators, and researchers. The CGR accepted the suggestion, and a meeting of the Convening Committee was held in Chicago, in December, 1986. The conference was scheduled for June 14-17, at Alfred University.

The Convening Committee was diligent in using both university and industrial contacts to solicit papers and to develop an International Advisory Board to assure international participation. The Convening Committee felt that interaction between attendees of the conference could be maximized during the limited time of the conference by having the published proceedings available at the time of the conference, and by allowing the authors the freedom to submit longer papers than has been customary at similar meetings. Thus, it was felt that authors could feel more free to concentrate on overviews during the limited time available for presentations, confident that the audience had the sustaining information readily available. It was thus felt that the overall conference would be more effective and that informal discussions between attendees would be stimulated. Therefore, manuscript limits were established of 30 pages for invited papers and 16 pages for contributed papers. Thus, to meet the time constraints the entire Convening Committee became the review and editorial staff, hence the unusually long list of Proceedings editors.

A unifying theme of the Conference was suggested as a search for excellence in glass products and processes. In particular, it was decided by the Convening Committee to solicit papers which explore commercially significant advances in glass production and products, to unify and compare the reasons for their success, and seek to explore new developments of significance. The logo for the conference is intended as a focal point for this comparison. It is similar to a triangle used for many years by Prof. Pye to introduce his students to the intricacies of the interrelated studies of processing, characterization, and properties. In recent months similar tetrahedra including applications as the fourth vertex have been used by the U.S. National Academy of Science to explain the interdisciplinary requirements of materials research, and by educators to discuss what constitutes an effective curricula for materials training (cf. G.J. Abbaschian and P.H. Holloway, "Views on a Comprehensive Materials Science and Engineering Education Program," MRS Bulletin, May/June, 1987, pp. 28-32). The specific diagram used by Abbaschian and Holloway has been modified for this logo. The most apparent change is the substitution of an SiO_2 tetrahedron as a unifying feature of the diagram, seeking to emphasize the conference's

focus on glass, since the SiO_2 tetrahedra are the essential building blocks of traditional glass production. Product development was added as an essential part of commercial success, which is necessary to produce the wealth necessary to sustain applied and basic research, and to generally improve the human condition. Process engineering was substituted for chemical engineering, to permit the inclusion of high temperature and solid state reactions, traditionally almost exclusively associated with process materials engineering.

Paul Vickers Gardner, Curator Emeritus and Consultant to the Smithsonian Institution, Washington, DC, accepted an invitation to deliver the plenary lecture, entitled "Highlights of Glass History." Mr. Gardner is a graduate of the Alfred University program in Ceramic Art, with postgraduate work in Journalism and the History of Art at the University of Miami. Mr. Gardner began his distinguished career as a designer and assistant to the world-renowned Frederick Carder of Steuben Glass and Corning Glass Works. He was the first Curator-in-Charge of the Division of Ceramics and Glass of the Smithsonian Institution's National Museum of American History. He continued his career at the Smithsonian until 1977, when he became Curator Emeritus and Consultant in order to devote full time to writing, lecturing, and pursuing a creative career in ceramics and glass. The author of three books and numerous papers on the history of glass design and glass making, Mr. Gardner brings a unique perspective to the plenary lecture and to discussions of glass and glass making.

With a theme, focus, a plenary lecture, and the establishment of a conference time and location, there remained the mechanics of producing a quality proceedings volume in the limited amount of time before the conference. An aggressive, and some might say optimistic, due date for manuscripts was established as March 1, 1988. This would permit 6 weeks for editing and assembling the manuscripts and 8 weeks to index, proof, print, bind, and transport the proceedings. It was decided to proceed with camera ready manuscripts but to format the papers in such a way that the text might be scanned with personal computer page scanners and reset in proportional fonts, with mattes printed with a laser printer. Thus, it was hoped that a more unified and legible proceedings volume would result than one resulting from various mechanically typed mattes. This experiment was supported by the American Ceramic Society through its Committee on Telecommunications in Publishing, and it has benefited from active support by the ACerS staff. The near typeset quality of laser printers was made available to all authors via this route, but a combination of late manuscript arrivals and slowing of the editing process to correct mis-scanned subscripts, superscripts, and Greek letters (common in these manuscripts) meant that the reformatting had to be limited to invited papers and a portion of the contributed papers which arrived first. Thus, the proceedings do not appear as uniform in appearance as was hoped, but the promise of this method is still apparent. An irregularity of line spacing exists in some texts as the result of automatic compensation for symbol, superscript, and subscript size, which was beyond the control of the editors. Given another opportunity, the senior editor would recommend an additional month for editing, rigid due dates, and acceptance of U.S. manuscripts only on floppy disk using exclusively one of the major personal computer word

processing programs available in the U.S. Foreign manuscripts should continue to be accepted in a typed format, to avoid unnecessary restrictions caused by the use of U.S. word processing programs, and would be page scanned, allowing the editors to clarify the text if necessary.

An undesired ramification of the combination of the use of page scanners and tight publication schedules was a reduced ability to have editorial changes reviewed by authors. Tables and figures have been printed essentially as delivered by authors to avoid errors in scanning or transcribing numerical information. The editors attempted to make changes in text only to unify the format, clarify and correct obvious typographic or grammatical errors, but there is a human tendency to rewrite in the editor's own style. The senior editor is solely responsible for errors of this kind, and apologizes for any difficulty this may have created. The content of each paper, of course, remains the contribution of the respective author(s).

Only time can determine if the goal of stimulating discussions between conference attendees by making the proceedings available at the time of the conference has been achieved. Overall, however, the editorial board is pleased with the content and appearance of the proceedings.

Dennis F. Bickford
Aiken, S. Carolina
June, 1988

GLASS RESEARCH AT THE NEW YORK STATE COLLEGE OF CERAMICS

Two separate but related entities of the New York State College of Ceramics support the glass research activities at the College. These are the Institute of Glass Science and Engineering (founded in 1984) and the NSF Industry-University Center for Glass Research (founded in 1985). The Institute supports long range goals of the College in all glass-related activities of the College, whereas the Center for Glass Research is a formal partnership among the National Science Foundation, the New York State College of Ceramics, and thirteen companies:

Alcoa
AFG Industries, Inc.
CertainTeed Corporation
Corning Glass Works
Ford Motor Company
Manville Building Materials Corp.
M & T Chemicals, Inc.
Owens-Illinois
Philips Glass
PPG Industries
Savannah River Laboratory
(E.I. du Pont de Nemours & Co.)
Specialty Products Company
U.S. Borax and Chemicals

The latter consortium was founded to promote research at the university level of interest to the Glass Industry and to train faculty, students, engineers, and scientists in glass science and engineering.

A further goal of the Center for Glass Research is to promote technology exchange among industry, academia, and government. It is one of forty centers sponsored by the National Science Foundation and at present involves over thirty faculty, students, and staff at the College of Ceramics.

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CONTENTS

HIGHLIGHTS OF GLASS HISTORY

Paul Vickers Gardner
Curator Emeritus and Consultant
Smithsonian Institution

I am honored and delighted to have been selected to give the plenary lecture for this important International Conference on Advances in the Fusion of Glass. I wish to thank L. David Pye, William C. LaCourse, and the others who have given me such a warm welcome and the privilege of addressing this distinguished group.

Throughout history, glass has reflected the tastes and needs of the cultures which fostered its productions. It has been glorified in magnificent stained glass windows and debased in throw away bottles and it continues to play an ever increasing role in science, engineering and art.

We do not know exactly when or where glass was first made. Most historians think some types of glass were produced at least as early as the 15th century B. C. probably in the Eastern Mediterranean area of Mesopotamia and Egypt.

Glass inlays imitating lapis lazuli are found ornamenting beaten gold masks and other articles from the tomb of King Tut Ankhamun 14th century B. C.

The oldest known dated glass vessel now in the Metropolitan Museum of Art in New York is the chalice/goblet with incised lotiform decorations and bearing the Cartouche of the Pharaoh Thotmos (Thotmosis) III about 1490 B. C.

Until glass blowing was discovered in the 1st century B. C. Glass items were luxury objects made by laborious time consuming processes for royalty and wealthy upper classes. The discovery of glass blowing revolutionalized the glass industry. This new process made ornamental and useful glass objects available at prices affordable by the masses as well as nobility.

Roman glass makers also produced luxury glass items which rivaled those of any other era. One of these outstanding artistic and technical achievements was cameo glass, exemplified by the Portland Vase made in the 1st century A. D. and now in the British Museum.

This world famous vase has fascinated scholars, historians, and artists/glass makers for centuries. In the late 19th century, English glass makers revived the art of cameo glass. John Northwood was paid 1000 pounds for his glass copy of the vase in 1876. Another English glass artist inspired by the Portland Vase was George Woodall who carved his masterpiece "Moorish Bathers" in the 1890's.

"Cage Cups" also called "Diatreta" are some of the rarest decorative glass pieces known. Most are attributed to Roman Empire glass artisans of the 4th century A. D. Less than 20 are known. Most were made in the Rineland and Italy but the most famous "Lycurgus Cup" may have been made in Egypt.

No glass is known to have been made by this technique since the 4th century until a German artist made a small cage cup in the 1950's and an American artist/glass maker, Barry Sautner, revised the technique in the 1980's. Using modern tools and techniques, he has achieved a mastery of the technique which rivals and sometimes surpasses anything