PREFACE

Although silicon nitride was discovered nearly a century ago, it is only in the last two decades that its potential as a structural material has been explored. Progress made in understanding the structure and properties of silicon nitride based materials has been reviewed every five years at NATO conferences and published in the form of proceedings entitled NITROGEN CERAMICS edited by F. L. Riley, Noordhoff (1977) and PROGRESS IN NITROGEN CERAMICS edited by F. L. Riley, Nijhoff (1983). At the first conference nitrogen chemistry was heavily emphasized and the current understanding of bonding and phase relations of the known compounds, of thermodynamics of powder formation reactions and densification were summarized, and preliminary efforts to understand structure/property relations presented. Research areas identified as requiring further work at the time were:

- phase relation determination in additional additive systems,
- fabrication and high temperature deformation processes,
- production of uniform, reproducible microstructures so that parameters of importance to mechanical properties could be isolated.

The significant progress made in the following five years was evident in the presentations at the second NATO conference. By 1983 most phases likely to be found in fabrication of silicon nitride based materials were characterized as were phase relations in a number of promising additive systems. Advancements made in developing procedures for evaluating mechanical properties both at ambient and high temperatures were also presented at this conference. Increasing toughness with silicon nitride grain aspect ratio had been reported. The observation that intergranular phases appeared to be continuous was critical because of its anticipated influence on high temperature creep resistance and oxidation resistance. Parallel developments in commercialization of engineering applications were outlined.

In spite of the tremendous advancements made during this ten year period, several critical issues remained unresolved. The potential of developing composites with crystalline secondary phases was indicated in yttria containing materials but was not fully exploited and required extensive phase equilibria studies in even more complicated systems. Properties were not yet correlated with microstructure because controlled crystallization and grain growth studies had not been carried out. Although the presence of residual intergranular phases was noted, their stability and structure were not understood. Hot pressing, clearly not economical for commercial applications, had been the primary densification method used in research; therefore, reproducible control through alternative processing techniques need to be developed. Application of silicon nitride in electronics industry had not been addressed.

The potential economic benefit from commercialization of applications has continued to motivate research efforts on fundamental concepts relating to, and technological aspects of, silicon nitride and related materials. Five years after the publication of the last NATO conference proceedings seemed an appropriate time to review the advancements made since the meeting and summarize our current understanding. Once again significant progress has been made on all fronts, in physics and chemistry of key mechanisms and processes as well as in engineering applications; therefore, it is not possible to list all of the contributions made during this time. We have attempted to present a broad perspective of the field by inviting a number of our colleagues who have made significant contributions over the years to summarize the current status of their fields. The evolution of this understanding is based on a number of recent experimental observations which are also presented here. Topics range from powder production, crystal chemistry and phase equilibria, microstructural development in monolithic silicon nitride and nitrogen glass ceramics, atomic structure of interfaces, thermomechanical and electrical properties, to applications including those in semiconductor device technology, reinforced composites, engine and wear components. This collection of papers indicates that 'silicon nitride based ceramic materials' has developed into a mature field.

The success of an ambitious undertaking such as compiling an overview of a dynamic field depends entirely on the efforts of the individual authors. We would like to express our gratitude to the authors for taking time to provide such comprehensive reviews.

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