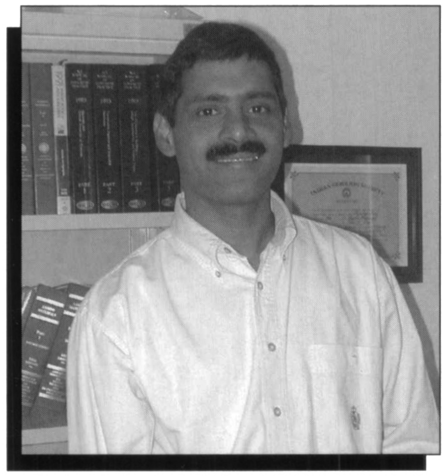
Ceramist Applies Materials Processing and Characterization Background to Innovative Product Development in Food Packaging

Amitabha Kumar

"I cook well. I can do this job." My current employer often repeats this statement as the one that impressed him during our first meeting in June 1994. At the time, I had accepted my current job with E. Khashoggi Industries at Santa Barbara, California, to work on materials for food packaging applications. Since then, the company has enabled the creation of a new technology for the manufacture of compostable starch-based composites. As a Senior Research Manager, my duties extend into understanding research needs for industrial deployment of the developed technology. I develop methods to facilitate application of our laboratory research in the field.

I started on the road to engineering with a degree in Ceramic Technology from Banaras Hindu University at Varanasi, India. This ceramic program emphasized chemical engineering and provided a sound base for an understanding of materials processing methods. Additionally, my father arranged for practical training during the summers of my engineering school years at various ceramic factories. This exposure to manufacturing at an early stage convinced me of the lack of proper interfaces between laboratory research and industrial needs. I obtained an MS and PhD degree in solid-state science at the Materials Research Laboratory at the Pennsylvania State University under Prof. Della M. Roy. My graduate work was on cementitious materials. This program also emphasized processing skills. A colleague at the graduate school once summed up our program as "one that taught many different processing and characterization methods." The cementitious materials studies introduced me to industrial waste materials and processes to contain them. This led to an interest in environmentally beneficial processes and materials. A professor at graduate school once mentioned, in passing, that students should not look toward their doctoral thesis as the only subject of future interest. This comment has made a lasting impact on my personal research goals. I did work as a postdoctoral fellow on advanced ceramic materials for application in superconductors and electronics materials. The experience was sufficient to indicate that processing skills were applicable even in these areas.

I worked for a few years in India in research and development projects to create industrial processes for the utilization of waste materials in ceramic products. The emphasis on the environment was clearly gaining an upper-hand in my research efforts. I tried to apply my knowledge into areas that concerned the environment while supporting my educational background. The two most important factors that attracted me to my present job were the commitment to the environment and the application of materials processing principles. The other important feature was the genuine innovative nature of the project. I was convinced that the model of ground-up research and development followed by industrial application would definitely result in a viable product. Over the last five years, beginning in 1994, the project has provided me with a number of experiences in such research and development. As a start-up company, the first phase was to create a product. The product had been identified even before I started on the job. My contribution was in the refinement of the processes required to make the product and in the modification of materials recipes.



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The product is an inorganic-organic fiber-reinforced composite that is foamed and set in a heated mold. The organic component is starch, used as a binder. The inorganic component is a natural or processed material such as limestone or calcined clay, used as a moderator, filler, or absorber. The fiber is a wood pulp, used as reinforcement. The developed processes used to make the product encompass normal ceramic processing techniques. Raw materials are evaluated using particle size, density, chemical analysis, and other properties generally used in ceramic materials characterization. Water, as steam, is used in the process to foam the article. Therefore the developed process relies heavily on hydrothermal processing.

This area of materials processing is a particular specialty of the Materials Research Laboratory at the Pennsylvania State University. The challenge was to extend acquired knowledge of materials science into an area of food chemistry and food processing. The knowledge of cooking really paid off and I thank my mother for the early training in self-sustenance! Starch chemistry is well-documented but the materials science of starch interaction with water in the presence of other materials and heat was specifically understood for this process during the course of the project. The knowledge of cement binder materials was especially relevant in developing the use of starch as a binder in the product. The application of fiber reinforcement in ceramic materials is well-understood. However, these fibers are generally synthetically produced. It was necessary to generate a process to utilize compostable fibers for this project. Earlier knowledge in fiber-reinforced ceramic materials assisted in the development of processes to incorporate wood pulp in the product. A mix of processing principles, materials science, chemistry, engineering, and a sequence of events provided a sufficient platform for the resulting product.

The early stage of product development was followed by extensive research and development to create industrial processes and methods. Since the product is a new material, existing machinery in the ceramic, chemical, or food processing industry is not directly applicable. Ex-

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perience with industrial research and equipment provided a basis for selection and screening of processing equipment. Concerted research and development permitted modification of machinery to suit the developed processes. The initial phase toward industrial production was to create a pilot plant with a unit operations approach to evaluate each step of the entire production process. Currently, after debugging and improvements by numerous colleagues, engineers, and vendors, the product is being manufactured on a large scale.

Structured development followed by structured implementation of innovations into the field for manufacture requires time before product can be inserted into the market. Constant changes in consumer demands over the last decade has created the requirement for rapid development and production of new materials. This rapid change can be achieved by adapting and retraining the knowledge base of those involved in the initial development and by short-circuiting development steps. Most start-up companies such as the one where I work utilize parallel development and production paths with an overlap of individuals. □

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Impurities in Engineering Materials: Impact, Reliability and Control

Clyde L. Briant, Editor
(Marcel Dekker, New York and Basel, 1999)
viii + 306 pages, $ 150.00
ISBN 0-8247-9965-8

Clyde Briant, the editor of this book, has a long and distinguished record, first in industry and recently at Brown University, studying impurity segregation to grain boundaries in alloys and the effects thereof on plasticity and fracture, going on to study the processing of refractory metals, especially tungsten which has to be "doped" to be used successfully in making lighting filaments. He is thus well-qualified as a progenitor of the book under review.

The nine chapters in this book are devoted to metallic systems, either in the form of ultrapure ("clean") alloy systems or to less pure materials in which impurities cause problems. Briant has written the first chapter, on the Need for Clean Materials, which is supplemented by an essay about clean superalloys by a former industrial colleague of the editor's, Mark Benz, and another on superclean steels by Allan Cramb of Carnegie-Mellon University. Three chapters focus in different ways on grain-boundary segregation and resultant embrittlement; one is a long chapter by a German metallurgist, Grabke (with a wealth of relevant references) on grain-boundary segregation specifically in steels, the others are by the editor, and by Easo George (Oak Ridge National Laboratory) and Richard Kennedy (Allvac), this last particularly informative piece focused on creep in relation to impurities. Eileen Skelly Frame, late of General Electric and now elsewhere in industry, has a most illuminating long chapter on the many analytical methods used for assessing impurities and their sensitivities. The late Jack Nutting (Leeds, England) has a somewhat pedestrian account of the sources of trace impurities, in steels particularly.

The focus of the book is thus somewhat narrow (there is nothing about ceramics, for instance) but it makes up for this in depth, and some of what appears here is capable of giving good ideas to non-metallurgists too. The chapters on ultraclean alloys are particularly illuminating for someone who has not kept up well with this aspect of modern metallurgy.

The book is somewhat expensive for what it provides, but then it is not alone in that nowadays. For readers and libraries that can afford it, it will most certainly not disappoint them.

Reviewer: Robert W. Cahn is a metallurgist as well as a materials scientist, attached to Cambridge University, and is a member of the MRS Bulletin *Book Review Board.*

Electronic Genie: The Tangled History of Silicon

Frederick Seitz and Norman G. Einspruch
(University of Illinois Press, Urbana and Chicago, 1998)
xvi + 281 pages, $34.95
ISBN 0-252-02383-8

Here is a historical volume which starts much further back than other books on the events that gave rise to the transistor. It is almost justifiable to say that much of it covers the prehistory of silicon. It covers the precocious researches of pioneers like the German Braun and Hollmann, and the American Pickard; the birth of interest in silicon at the same time as wireless telegraphy began; and the early, tentative steps toward an understanding of how semiconductors as a class work. The roles of radar research in Germany, France, Russia, Japan, and Britain receive separate chapters, some very short. Several physicists loom large in these early stories, for instance, the Britons Denis Robertson (who later settled in America) and Herbert Skinner. Bell Labs do not raise their corporate head until chapter 13 (out of a total of 20), and the story of the "discrete transistor" occupies a lively chapter 14. The last chapters expertly review integrated circuits and possible futures. The book is very well provided with portrait photographs of the many actors in this tangled drama; this feature is always a special strength of books in which Seitz is involved.

The book has had a complex prehistory of its own and involved much archival research by the authors; the Acknowledgments occupy all of six pages, which indicates how complex the historical research was. The book's immediate precursor was a paper by Seitz in the *Proceedings of the American Philosophical Society* **140** (1996) 289.

For any reader who wants to know how the information age came about, this book is compulsory reading, as a necessary companion to Riordan and Hoddeson's book, *Crystal Fire* (1997).

Reviewer: Robert W. Cahn is a metallurgist as well as a materials scientist, attached to Cambridge University, and is a member of the MRS Bulletin *Book Review Board.*

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