



Processing and Applications of Nanostructured Ceramics

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Methods will be described for the production and consolidation of metastable ceramic powders to yield fully dense nanostructured ceramics, including single- and multi-phase systems. Metastable powders produced by vapor condensation or rapid solidification are consolidated to full density by high-pressure sintering or field-assisted sintering. In each case, the key to successful consolidation is control of a metastable-to-stable phase transformation that occurs during sintering, which promotes densification, enhances sintering kinetics, and minimizes grain growth. For single-phase or nanocrystalline ceramics, high pressures in the 1-8 GPa range are needed to achieve densification, without causing significant grain growth. For multi-phase or nanocomposite ceramics, the pressure requirements are relaxed to the 0.1-0.5 GPa range. This is because upon co-nucleation of the equilibrium phases during sintering, the presence of one nanophase quite naturally inhibits the growth of an adjacent nanophase(s), particularly when the volume fractions are comparable. Because of the reduced pressure requirements, processing of nanocomposite ceramics is more readily commercialized. Nanocomposite ceramics also display high strain rate superplasticity, which opens unprecedented opportunities for near-net shape superplastic forming. In this talk, these and related aspects of this new far-from-equilibrium processing technology will be discussed, as well as potential applications in lightweight personnel armor, IR-transparent domes, high power lasers, machine tools, and rock-drill bits.

Professor Bernard H. Kear received his B.Sc., Ph.D. and D.Sc. degrees in Materials Science and Engineering from University Birmingham, England. From 1960-63 he was with the Franklin Institute in Philadelphia where he studied the effects of long-range ordering on the plastic properties of crystals. From 1963-81 he was with the Pratt & Whitney Division of United Technologies Corporation, where he investigated the relationships between structure/properties/processing in superalloys, participated in the development of single crystal turbine blade technology, and spearheaded the development of laser surface modification treatments. From 1981-86, he was Scientific Advisor at Exxon's Corporate Research Center, where he conducted research in chemical vapor deposition, and its applicability to surface modification of reactor vessels and upgrading of the surface properties of steel structures. In 1986 he assumed his present position as State of New Jersey Professor of Materials Science and Technology, and Director of the Center for Nanomaterials Research (CNR). His research activities at CNR have been focused on the synthesis and processing of nanophase materials by solution, flame and plasma methods, surface treatments by thermal spraying of nanophase powders, liquid phase sintering of nanophase cermets, and pressure-assisted sintering of nanophase oxide and non-oxide ceramics, diamond and fullerenes. Kear has published 300 papers, has edited 10 books, and has been granted 40 patents. He was awarded the Howe Medal of ASM in 1970 and the Mathewson Gold Medal of TMS-AIME in 1971. He was elected to the National Academy of Engineering in 1979. From 1983, he served as a member of the National Materials Advisory Board and was Chairman from 1986-1989.

