January 30, 2018

Rishi Raj

Tel: (303) 492-1029
Fax: (303) 492-3498
rishi.raj@colorado.edu

Department of Mechanical Engineering,
University of Colorado at Boulder, CO, US 80309-0427

Professional Preparation

Allahabad University (India)	Pure Sciences	B.Ss.	1961
University of Durham (England)	Elect. Eng.	B.Sc (Hons I)	1964
Harvard University (Cambridge, MA)	Eng. & App. Science	Ph.D.	1970

Appointments

1996 – present	Professor of Mechanical Engineering, University of Colorado at Boulder, CO
1975 – 1996	Professor of Materials Science and Engineering, Cornell University, Ithaca, NY
1972 – 1975	Assist. Professor of Mechanical Engineering, University of Colorado at Boulder, CO
1971-72	Staff Scientist, Chase Brass and Copper Company, Cleveland, OH
1964-65	Staff Engineer, Standard Telephones and Cables Ltd, London N10, England.
1980	Scientist, Rockwell Science Center, Thousand Oaks, CA

Awards

•2017, Served as Distinguished Visiting Fellow of the Royal Academy of Engineering (UK).

•2015, Elected Distinguished Life Member of the American Ceramic Society – the highest honor conferred upon the Members of the Society;

•2013, Edward C. Henry Best Paper Award, with J-C M'Peko, J.S.C. Francis, "Impedance Spectroscopy and Dielectric Properties of Flash versus Conventionally Sintered Yttria-Doped Zirconia Electroceramics viewed at the Microstructural Level", American Ceramic Society.

•2011-2017, Distinguished Chair Professor at POSTECH, Korea South;

•2011-2012, Japan Society for Promotion of Science Fellowship to Tokyo Tech, Japan

•2004, Aditya Birla Chair Professor of Mechanical Engineering (an Honorary appointment), Indian Institute of Science, Bangalore, India;

•1996, John Matthias Scholar, Los Alamos National Laboratory;

•1992, Alexander von Humboldt Senior Scientist Awardee, Max Planck Institute for Metal Research in Stuttgart, Germany;

•1985, Guggenheim Fellow.

•1964, John Mather and Mauder Howe Prizes from the University of Durham, England;

•1961, Gold Medals in Chemistry and Mathematics, Allahabad University, India.

Google Scholar

h-Index: 72

Total number of citations: more than 19,000

Summary of Research

The research in my group is concentrated in two areas: flash sintering, and high temperature ceramic-matrix-composites from polymer derived ceramics.

Flash sintering was first discovered in our laboratory in 2010. It is being heralded as the most significant discovery in the field of Ceramics over the last twenty-five years, with both scientific and technological implications for the coming decades. The field has spread to many laboratories throughout the world, often through visitors to our laboratory who have then returned to their own institutions and established their own programs. Just recently, two very large, multiyear, multi-investigator programs have been established in Germany (Juelich) and Japan (NIMS). The science of flash sintering is highly interdisciplinary spanning across materials science, physics, electrical engineering and computer science.

There is emerging interest in using the method to process ceramics for next generation solid state Li-ion batteries, which is often not possible by conventional techniques.

Lucideon became interested in our work early on and is now developing commercial opportunities for flash sintering in various applications.

Grant Expenditures

Grants from DOE-BES, NSF, ONR, ARO, ARPA-E, Industry (Lucideon, UK)

2016: $616,538

2015: $873,339

2014: $716,304

2013: $758,833

National and International Service Activities

•Conceptualized, Chaired, lobbied for participants and raised funds from ARO and ONR for an Engineering Conference International Conference on “Field Assisted and Flash Sintering” held in Tomar, Portugal, March 04-09, 2016.

•Worked with Prof. Gurpreet Singh to enable a PIRE (Partners for International Research and Education Grant) grant from the NSF on Polymer-Derived Ceramic Fibers; a five year, $1M per year grant with participants from US, Germany, Italy, France, India and Japan. Start date: 01/01/2018.

•Founding Organizer of Boulder International Workshops on Polymer Derived Ceramics: 1998, 2000, 2002, 2010, 2012, and 2014: laid the foundation for building a community in a fledging field of research.

•Chair of the Materials Division of ASME, 2001-2002. Executive Committee 1997-2002.

•Established a Dual Ph.D. program between Department of Materials and Industrial Engineering University of Trento, and Mechanical Engineering from the University of Colorado at Boulder.

Mentorship

Raj has supervised the doctoral thesis of more than 60 Ph.D. students, as well as approximately 20 Post-Doctoral Research Associates, and 25 Masters Thesis students. A very large number of undergraduates, about two or three per year for the last 45 years have gained laboratory experience under his guidance.

There are usually three or so visitors from international institutions to his laboratory who come here for extended stays to participate and collaborate in research.

Publications

More than 375 publications in refereed Interanational Journals:
https://scholar.google.com/citations?user=YcKlmjEAAAAJ&hl=en&oi=ao

Publications for the past five years.

2018

(1) Gil-González E, Perejón A, Sánchez-Jiménez PE, Sayagués MJ, Raj R, Pérez-Maqueda LA. Phase-pure BiFeO 3 produced by reaction flash-sintering of Bi 2 O 3 and Fe 2 O 3. Journal of Materials Chemistry A. 2018.

2017

(1) Chelliah NM, Singh H, Raj R, Surappa MK. Processing, microstructural evolution and strength properties of in-situ magnesium matrix composites containing nano-sized polymer derived SiCNO particles. Materials Science and Engineering: A. 2017 Feb 8;685:429-38.

(2) Kok D, Jha SK, Raj R, Mecartney ML. Flash sintering of a three-phase alumina, spinel, and yttria-stabilized zirconia composite. Journal of the American Ceramic Society. 2017 Jul 1;100(7):3262-8.

(3) McLaren C, Roling B, Raj R, Jain H. Mechanism of electric field-induced softening (EFIS) of alkali silicate glasses. Journal of Non-Crystalline Solids. 2017 Sep 1;471:384-95.

(4) Seo HK, Kim K, Min SY, Lee Y, Park CE, Raj R, Lee TW. Direct growth of graphene-dielectric bi-layer structure on device substrates from Si-based polymer. 2D Materials. 2017 Jan 11;4(2):024001.

(5) Yadav D, Raj R. Two Unique Measurements Related to Flash Experiments with Yttria Stabilized Zirconia. Journal of the American Ceramic Society. 2017.

(6) Yoon B, Yadav D, Raj R, Ghose S, Sarin P, Shoemaker D. Measurement of O and Ti atom displacements in TiO2 during flash sintering experiments. Journal of the American Ceramic Society. 2017 Dec 29.

(7) Perez-Maqueda LA, Gil-Gonzalez E, Perejon A, Lebrun JM, Sanchez-Jimenez PE, Raj R. Flash Sintering of highly insulating nanostructured phase-pure BiFeO3. Journal of the American Ceramic Society. 2017 Aug 1.

(8) Chelliah NM, Kraemer L, Singh H, Surappa MK, Raj R. Stress–rupture measurements of cast magnesium strengthened by in-situ production of ceramic particles. Journal of Magnesium and Alloys. 2017 Jun 1;5(2):225-30.

(9) Lebrun JM, Hellberg CS, Jha SK, Kriven W, Steveson A, Seymour KC, Bernstein N, Erwin SC, Raj R. In-situ Measurements of Lattice Expansion Related to Defect Generation During Flash Sintering. Journal of the American Ceramic Society. 2017 Jul 19.

(10) Chelliah NM, Kraemer L, Singh H, Surappa MK, Raj R. A Polymer Route to the Design of Thermally Stable Metal Matrix Composites: Materials Selection and In-situ Processing. Research and Reports on Metals. 2017 Dec 4;2017.

(11) Hu LH, Ceccato R, Raj R. Tunable hydrogen generation from sodium borohydride with silicon carbonitride functionalized carbon nanostructure electrode. international journal of hydrogen energy. 2017 Feb 23;42(8):5447-54.

(12) Raj R, inventor; American Manufacturing, Inc., assignee. Additive Manufacturing of Polymer Derived Ceramics. United States patent application US 15/042,992. 2017 Aug 17.

(13) Sortino E, Lebrun JM, Sansone A, Raj R. Continuous flash sintering. Journal of the American Ceramic Society, 2017;00:1– 9.

(14) Raj R, Ramanathan S. Flash transition as a possible origin for low open circuit voltage in thin film solid oxide fuel cells. Journal of Power Sources. 2017 Aug 15;359:48-51.

(15) Raj R, Wolfenstine J. Current limit diagrams for dendrite formation in solid-state electrolytes for Li-ion batteries. Journal of Power Sources. 2017 Mar 1;343:119-26.

(16) Yadav D, Raj R. The onset of the flash transition in single crystals of cubic zirconia as a function of electric field and temperature. Scripta Materialia. 2017 Jun 30;134:123-7.

2016

(1) Jha SK, Lebrun JM, Seymour KC, Kriven WM, Raj R. Electric field induced texture in titania during experiments related to flash sintering. Journal of the European Ceramic Society. 2016 Jan 31;36(1):257-61.

(2) Zoli L, Sciti D, Liew LA, Terauds K, Azarnoush S, Raj R. Additive manufacturing of ceramics enabled by flash pyrolysis of polymer precursors with nanoscale layers. Journal of the American Ceramic Society. 2016 Jan 1;99(1):57-63.

(3) Jha SK, Lebrun JM, Raj R. Phase transformation in the alumina–titania system during flash sintering experiments. Journal of the European Ceramic Society. 2016 Feb 29;36(3):733-9.

(4) Shinoda Y, Raj R, Minoguchi Y, Akatsu T, Wakai F. Hafnia-silicon carbide nanocomposites II: Measurements of the residual stress. Journal of the European Ceramic Society. 2016 Feb 1;36(3):937-42.

(5) Lebrun JM, Jha SK, Naik KS, Seymour KC, Kriven WM, Raj R. The Change of X-ray Diffraction Peak Width During in situ Conventional Sintering of Nanoscale Powders. Journal of the American Ceramic Society. 2016 Mar 1;99(3):765-8.

(6) Bajpai I, Han YH, Yun J, Francis J, Kim S, Raj R. Preliminary investigation of hydroxyapatite microstructures prepared by flash sintering. Advances in Applied Ceramics. 2016 Jul 3;115(5):276-81.

(7) Naik K, Jha SK, Raj R. Correlations between conductivity, electroluminescence and flash sintering. Scripta Materialia. 2016 Jun 1;118:1-4.

(8) Liao N, Zhang M, Raj R, Zhou S. Predicting structural properties of amorphous silicon carbonitride by atomistic simulation. International Journal of Materials and Structural Integrity. 2016;10(1-3):63-9.

(9) Azarnoush S, Laubscher F, Zoli L, Raj R. Additive Manufacturing of SiCN Ceramic Matrix for SiC Fiber Composites by Flash Pyrolysis of Nanoscale Polymer Films. Journal of the American Ceramic Society. 2016 Jun 1;99(6):1855-8.

(10) Raj R. Analysis of the power density at the onset of flash sintering. Journal of the American Ceramic Society. 2016 Oct 1;99(10):3226-32.

(11) Jha SK, Terauds K, Lebrun JM, Raj R. Beyond flash sintering in 3 mol% yttria stabilized zirconia. Journal of the Ceramic Society of Japan. 2016 Apr 1;124(4):283-8.

(12) Lebrun JM, Jha SK, McCormack SJ, Kriven WM, Raj R. Broadening of diffraction peak widths and temperature nonuniformity during flash experiments. Journal of the American Ceramic Society. 2016 Oct 1;99(10):3429-34.

(13) Jesus LM, Silva RS, Raj R, M'Peko JC. Electric field-assisted flash sintering of CaCu3Ti4O12: Microstructure characteristics and dielectric properties. Journal of Alloys and Compounds. 2016 Oct 15;682:753-8.

(14) Corapcioglu G, Gulgun MA, Kisslinger K, Sturm S, Jha SK, Raj R. Microstructure and microchemistry of flash sintered K0. 5Na0. 5NbO3. Journal of the Ceramic Society of Japan. 2016 Apr 1;124(4):321-8.

(15) Jesus LM, Silva RS, Raj R, M'Peko JC. Electric field-assisted ultrafast synthesis of nanopowders: a novel and cost-efficient approach. RSC Advances. 2016;6(109):107208-13.

(16) Saleh I, Raj R. Three-dimensional architecture of lithium-anodes made from graphite fibers coated with thin-films of silicon oxycarbide: Design, performance and manufacturability. Journal of Power Sources. 2016 Apr 1;310:18-25.

2015

(1) Castellan E, Kailas SV, Madayi S, Raj R. Low-Wear High-Friction Behavior of Copper Matrix Composites Dispersed With an In Situ Polymer Derived Ceramic. Journal of Tribology. 2015 Apr 1;137(2):024501.

(2) Narisawa M, Terauds K, Ma G, Hokazono H, Raj R, Iwase A. Evaluation of high temperature resistance of white Si–O–C (–H) ceramics in an inert atmosphere. Journal of Non-Crystalline Solids. 2015 Feb 15;410:106-11.

(3) Karakuscu A, Hu LH, Ponzoni A, Baratto C, Ceccato R, Sberveglieri G, Raj R. SiOCN functionalized carbon nanotube gas sensors for elevated temperature applications. Journal of the American Ceramic Society. 2015 Apr 1;98(4):1142-9.

(4) Lebrun JM, Morrissey TG, Francis JS, Seymour KC, Kriven WM, Raj R. Emergence and extinction of a new phase during on–off experiments related to flash sintering of 3YSZ. Journal of the American Ceramic Society. 2015 May 1;98(5):1493-7.

(5) Hu LH, Raj R. Semiconductive Behavior of Polymer-Derived SiCN Ceramics for Hydrogen Sensing.

Journal of the American Ceramic Society. 2015 Apr 1;98(4):1052-5.

(6) Terauds K, Lebrun JM, Lee HH, Jeon TY, Lee SH, Je JH, Raj R. Electroluminescence and the measurement of temperature during Stage III of flash sintering experiments. Journal of the European Ceramic Society. 2015 Oct 31;35(11):3195-9.

(7) Raj R, Terauds K. Bubble nucleation during oxidation of SiC. Journal of the American Ceramic Society. 2015 Aug 1;98(8):2579-86.

(8) Kumar A, Raj R, Kailas SV. A novel in-situ polymer derived nano ceramic MMC by friction stir processing. Materials & Design. 2015 Nov 15;85:626-34.

(9) Pereira da Silva JG, Lebrun JM, Al-Qureshi HA, Janssen R, Raj R. Temperature Distributions During Flash Sintering of 8% Yttria-Stabilized Zirconia. Journal of the American Ceramic Society. 2015 Nov 1;98(11):3525-8.

(10) Yu L, Raj R. On the thermodynamically stable amorphous phase of polymer-derived silicon oxycarbide. Scientific reports. 2015 Sep 30;5:14550.

(11) McLaren C, Heffner W, Tessarollo R, Raj R, Jain H. Electric field-induced softening of alkali silicate glasses. Applied Physics Letters. 2015 Nov 2;107(18):184101.

(12) Çorapcıoğlu G, Gülgün MA, Raj R. Flash sintering of lead-free K0. 5Na0. 5NbO3 ceramics. Journal of the Ceramic Society of Japan. 2015 Nov 18.

2014

(1) Weidman PD, Ahn D, Raj R. Diffusive relaxation of Li in particles of silicon oxycarbide measured by galvanostatic titrations. Journal of Power Sources. 2014 Mar 1;249:219-30.

(2) Terauds K, Raj R. Dramatic influence of interface chemical potentials on the oxidation of silicon and carbon based compounds. Journal of the European Ceramic Society. 2014 Apr 1;34(4):1035-9.

(3) Yoshida H, Sakka Y, Yamamoto T, Lebrun JM, Raj R. Densification behaviour and microstructural development in undoped yttria prepared by flash-sintering. Journal of the European Ceramic Society. 2014 Apr 1;34(4):991-1000.

(4) Sudarshan, Terauds K, Anilchandra AR, Raj R. Polymer-derived in-situ metal matrix composites created by direct injection of a liquid polymer into molten magnesium. Metallurgical and Materials Transactions A. 2014 Feb 1;45(2):551-4.

(5) Jha SK, Raj R. The effect of electric field on sintering and electrical conductivity of titania. Journal of the American Ceramic Society. 2014 Feb 1;97(2):527-34.

(6) Terauds K, Raj R, Kroll P. Ab inito and FTIR studies of HfSiCNO processed from the polymer route. Journal of the American Ceramic Society. 2014 Mar 1;97(3):742-9.

(7) Shinoda Y, Marshall DB, Raj R. Oxidation, mechanical and thermal properties of hafnia–silicon carbide nanocomposites. Journal of the European Ceramic Society. 2014 Jul 1;34(7):1783-90.

(8) Naik KS, Sglavo VM, Raj R. Field assisted sintering of ceramic constituted by alumina and yttria stabilized zirconia. Journal of the European Ceramic Society. 2014 Sep 1;34(10):2435-42.

(9) Lebrun JM, Raj R. A first report of photoemission in experiments related to flash sintering. Journal of the American Ceramic Society. 2014 Aug 1;97(8):2427-30.

(10) Liu J, Sahaym U, Dutta I, Raj R, Renavikar M, Sidhu RS, Mahajan R. Interfacially engineered liquid-

phase-sintered Cu–In composite solders for thermal interface material applications. Journal of materials science. 2014 Nov 1;49(22):7844-54.

(11) Jha SK, Raj R. Electric fields obviate constrained sintering. Journal of the American Ceramic Society. 2014 Oct 1;97(10):3103-9.

(12) Soignard E, Hochheimer HD, Yarger J, Raj R. Reversible elastic deformation of functionalized sp2 carbon at pressures of up to 33 GPa. Applied Physics Letters. 2014 Oct 6;105(14):141901.

(13) Trombin F, Raj R. Developing processing maps for implementing flash sintering into manufacture of whiteware ceramics. Am. Ceram. Soc. Bull. 2014 Aug 1;93:32-5.

2013

(1) Castellan E, Ischia G, Molinari A, Raj R. A Novel In Situ Method for Producing a Dispersion of a Ceramic Phase into Copper That Remains Stable at 0.9T M. Metallurgical and Materials Transactions A. 2013 Oct 1;44(10):4734-42.

(2) Francis JS, Raj R. Influence of the field and the current limit on flash sintering at isothermal furnace temperatures. Journal of the American Ceramic Society. 2013 Sep 1;96(9):2754-8.

(3) Raj R, Krumdieck SP. A Langmuir-Kinetic Model for CVD Growth from Chemical Precursors. Chemical Vapor Deposition. 2013 Sep 1;19(7-8-9):260-6.

(4) Abdulagatov AI, Terauds KE, Travis JJ, Cavanagh AS, Raj R, George SM. Pyrolysis of titanicone molecular layer deposition films as precursors for conducting TiO2/carbon composite films. The Journal of Physical Chemistry C. 2013 Aug 19;117(34):17442-50.

(5) Terauds K, Marshall DB, Raj R. Oxidation of Polymer-Derived HfSiCNO up to 1600° C. Journal of the American Ceramic Society. 2013 Apr 1;96(4):1278-84.

(6) Terauds K, Raj R. Limits to the Stability of the Amorphous Nature of Polymer-Derived HfSiCNO Compounds. Journal of the American Ceramic Society. 2013 Jul 1;96(7):2117-23.

(7) Raj R. Chemical Potential-Based Analysis for the Oxidation Kinetics of Si and SiC Single Crystals. Journal of the American Ceramic Society. 2013 Sep 1;96(9):2926-34.

(8) Francis JS, Cologna M, Montinaro D, Raj R. Flash sintering of anode–electrolyte multilayers for SOFC applications. Journal of the American Ceramic Society. 2013 May 1;96(5):1352-4.

(9) Behera SK, Raj R. Extreme-rate capable and highly stable SiCO–TiO 2 hybrids for Li ion battery anodes. Chemical Communications. 2013;49(83):9657-9.

(10) M'Peko JC, Francis JS, Raj R. Impedance Spectroscopy and Dielectric Properties of Flash Versus Conventionally Sintered Yttria-Doped Zirconia Electroceramics Viewed at the Microstructural Level. Journal of the American Ceramic Society. 2013 Dec 1;96(12):3760-7.

(11) Raj R, Rehman A. Can Die Configuration Influence Field-Assisted Sintering of Oxides in the SPS Process?. Journal of the American Ceramic Society. 2013 Dec 1;96(12):3697-700.

(12) Conrad H. Grain boundary resistivity of yttria-stabilized zirconia at 1400 C. Journal of Ceramics. 2013 Mar 12;2013.

(13) Raj R, Cologna M, Prette AL, Sglavo VM, Francis J, inventors; University of Colorado Boulder, assignee. Methods of flash sintering. United States patent US 8,940,220. 2015 Jan 27.

(14) Won J, Vernon LJ, Karakuscu A, Dickerson RM, Cologna M, Raj R, Wang Y, Yoo SJ, Lee SH, Misra

A, Uberuaga BP. The role of non-stoichiometric defects in radiation damage evolution of SrTiO 3. Journal of Materials Chemistry A. 2013;1(32):9235-45.

(15) Narisawa M, Terauds K, Raj R, Kawamoto Y, Matsui T, Iwase A. Oxidation process of white Si–O–C (–H) ceramics with various hydrogen contents. Scripta Materialia. 2013 Oct 1;69(8):602-5.

(16) Raj R, Surappa MK, inventors; Indian Institute of Science, assignee. Process for preparation of nano ceramic-metal matrix composites and apparatus thereof. United States patent US 8,540,797. 2013 Sep 24.

Collaborators

Numerous from Italy, Japan, Germany, Brazil and India.

Also several from other Universities and Institutions in the United States (Los Alamos National Laboratory, Sandia National Laboratory, Colorado State University, Arizona State University, Lehigh University, Kansas State University, Argonne National Laboratory and Brookhaven National Laboratory, Washington State University).