Metin Tülümen et al., Res. Rev. J Mat. Sci. 2018, Volume 6
DOI: 10.4172/2321-6212-C1-014

Process development for the ceramic injection molding of oxide short fiber reinforced CMCs

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Ceramic matrix composites (CMCs) are created by adding fibers with variety of fiber structure into various ceramic materials to provide condition / task adapted properties. On the other hand, ceramic injection molding is an automated net shaping process that can produce the ceramic parts with complex geometry and good surface quality without the requirement for a post-processing step. In this study, we produced aluminum oxide CMCs (Al_2O_3 powder: TMDAR, Taimicron; Al_2O_3 chopped fibers: 3M Nextel 610) by using ceramic (µ-) injection molding process. Each step such as feedstock preparation, molding step, debinding or sintering, has significant effect on the final properties of the CMCs parts. Measurement of density as a function of time, temperature, fiber content or -orientation coupled with the examination of the final microstructure is a useful method to evaluate the ceramic parts. The relative density of sintered CMC parts (sintered from 1150 to 1350 2h) decreased at about 35% with increasing amount of oxide chopped fibers from 0 to 25 Vol. % in feedstock including polymer binding system. The reason of such a low sintering temperature for aluminum oxide based material is to prevent the grain growth in the fibers [1]. In addition, the form of the injection mold design defines the fiber orientation that differentiate the density and mechanical properties of the sintered parts. The difference between tensile specimen (higher orientation) and disc form (random orientation) is about from 1 to 10% depending on temperature and the amount of fiber in the feedstock. On the other hand, whether it is hard to define the mechanical characteristic because of highly deformed sintered parts, our first impression on the results is that the fiber reinforced injection molded parts have lower fracture toughness than common CMC parts with endless fibers or fabric.

Figure 1: Fiber orientation and distribution in the neck region of a sintered (at 1250 °C) tensile specimen.

Recent Publications

1. Tülümen M, Hanemann T, Hoffmann M, Oberacker R, Piotter V. (2017). Process Development for the Ceramic Injection Molding of Oxide Chopped Fiber Reinforced Aluminum Oxide. Key Engineering Materials. 742. 231-237. DOI: 10.4028
2. Piotter, V., Hanemann, T., Heldele, R. Mueller, M., Mueller, T., Plewa, K., Ruh, A. (2010) Metal and Ceramic Parts Fabricated by Microminiature Powder Injection Molding, Int. Journal of Powder Metallurgy, Vol. 46, 2, 21-28.
3. Piotter, V., Bauer, W., Knitter, R., Mueller, M., Mueller, T., Plewa, K. (2010) Powder injection molding of metallic and ceramic microparts, Microsystem Tech., 17, 251-263
4. Piotter, V., Prokop, J., Ritzhaupt-Kleissl, H.-J., Ruh, A., Hausselt, J. (2010) Multi-component microinjection moulding-trends and developments; International Journal of Advanced Manufacturing Technology 47, 63-71.
5. Ruh, A., Hanemann, T., Heldele, R., Piotter, V., Ritzhaupt-Kleissl, H.-J., Haußelt, J. (2011) Development of Two-Component Micropowder Injection Molding (2C MicroPIM): Characteristics of Applicable Materials; Int. J. Appl. Ceram. Technol. 8, 194-202.

Biography

Metin Tülümen is a PhD Student at University Freiburg, Germany and working as a research associate in institute of applied materials at Karlsruhe Institute of Technology, working with Prof. Dr. Thomas Hanemann. He earned his Master of Science on materials science and with specialization of glass and ceramics at Clausthal University of Technology, Germany. In his PhD thesis he is developing and characterize new molding compounds containing short ceramic fibers for powder injection processes.

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