Interest of Spark Plasma Sintering to obtain Optoceramics versus Crystals

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Conventional transparent materials have a strong absorption in the infrared region making them unsuitable in this spectral range. Transparent ceramics with nanograins is one of the widely studied topics by the ceramics society, could be an alternative. In order to obtain the transparent ceramics, it is important to obtain maximum density and porosity in the orders of 100 ppm < 0.01 vol % and $\varnothing_m < \lambda/10$. Various sintering parameters interplay to obtain the desired result, where the prime factors being sintering temperature (T_s), dwell time (t) and Pressure (P_s) and the point of pressure application (A_P). With the help of the aforesaid sintering parameters, it is necessary to optimize the conditions to obtain optimal grain size, density and porosity. Other than the grain boundaries, porosity is one of the main scattering centers of light. In order to obtain the minimal porosity, it is necessary to stay at high sintering temperatures for long time, but at the risk of grain growth, which will impede the transparency of the ceramics. Conventionally optically transparent ceramics are often fabricated by either hot-isostatic pressing (HIP), or hot pressing (HP) or vacuum sintering at very high temperatures using ultrapure ultrafine powders. Rapid sintering techniques such as Spark Plasma Sintering (SPS) helps in obtaining maximum densification in short duration of time at comparatively lesser sintering temperatures in comparison to other classical sintering. Simultaneous application of pressure and the help of Joules heating aids in avoiding Ostwald's ripening [1]. Most of the current transparent ceramics are limited only to cubic materials, currently extended to non-cubic materials as well though in early stages. At ICMCB, we have demonstrated successfully the fabrication of transparent ceramics of both cubic and non-cubic crystal structured materials by combining the high sinterability of nanocrystalline (nc) powders with the rapid densification rates characteristic of spark plasma sintering (SPS) [2]. Few examples of transparent ceramics fabricated at ICMCB [3, 4] by SPS are Yb^{3+}:Lu_2O_3, Yb^{3+}:Gd_2O_3, Yb^{3+}:Sc_2O_3, Yb^{3+}: Y_2O_3, ZnO, YAG, Yb^{3+}: YAG, $MgAl_2O_4$, ZrO_2 and ZnSe. The fabrication methodology and results will be discussed in detail.

References:

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