LAPHIA seminar : Opto-ceramics: development and potential applications

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Tremendous efforts over the past six decades has lead to huge progress in advanced solid state and lasers for energy and power scaling [1,2]. In the present scenario, solid state crystals though are ideal for applications, primarily in terms of compactness and user friendly, these types of crystals are difficult to be grown due to the high temperature growth issues, which limit size and quality. Transparent / opto-ceramics processing with nano-sized ceramic powders and advanced densification technology provide an alternative approach to overcome the disadvantages/ limits of conventional single-crystal growth methods. It would be much easier to elaborate polycrystalline ceramics with a full densification state and a homogeneous chemical composition under sintering temperature much lower than its melting point with a relative low cost and size flexibility. Transparent ceramics found fast development in late 20th century. Transparent ceramics have potential applications in various optical fields such as night vision, electro-optic, scintillation, infra-red, armor, laser, missiles etc., The recent progress in the development of nano-sciences and technology led to the development of transparent ceramics and advanced ceramic processing sciences and technology by intentionally, superimposing and refining the fundamental properties of ceramic materials. Though transparent ceramics have lower transmittance than single crystals has higher mechanical strength and large flexibility to fabricate into complex shapes in short duration ranging from minutes to hours.

In the last few years, there is an enormous progress in the efficiency and performance levels of polycrystalline optical ceramics due to the texturing and domain engineering [3], primarily in the transparent laser ceramics and ferroelectrics. In the aforesaid cases, the minute changes in the scale of optical wavelength of microstructures leads to a vast difference in the properties and their behavior. However, most of the current transparent ceramics were limited only to the cubic materials, currently extended to non-cubic materials as well though in early stages. If the polycrystalline anisotropic ceramics are available by the sintering method, a tremendous breakthrough should be expected in the cutting edge of photonics. Investigations on obtaining optically transparent anisotropic ceramics will enable to create reliable device quality systems in place of conventional single crystals. Conventionally optically transparent ceramics are often fabricated primarily by vacuum sintering at very high temperatures or by more complicated processes such as hot isostatic pressing (HIP), or hot pressing (HP) using ultrapure and ultrafine powders. 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 powders with the rapid densification, characteristic of spark plasma sintering (SPS) [4]. Few examples of transparent ceramics fabricated at ICMCB [5, 6] by SPS are Sesquioxides, Chalcogenides, Spinel, ZnO, Yb^{3+}:YAG, Al_2O_3 and ZrO_2 their fabrication methodologies and results will be discussed in detail.

References:

[1] *Astronautics*: 74. March 1962. [2] N. P. Barnes, Transition metal solid-state lasers, in *Tunable Lasers Handbook*, F. J. Duarte (Ed.) (Academic, New York, 1995). [3] Y.Watanabe et al., J. Amer. Ceram. Soc. 88 (2005) 243–245. [4] ZA Munir et al., Journal of Materials Science 41 (2006) 763–777. [5] M.Prakasam et. al., Ceramics International 39 (2013) 1307–1313. [6) M.Prakasam et. al., Ceramics International (In press) http://dx.doi.org/10.1016/j.ceramint.2013.07.088