KY_3F_{10} ceramic

On the Host Lattice KY_3F_{10} Doped by Trivalent Praseodymium as a Transparent Ceramic Laser Material

Sponsored by the Federal Ministry of Education and Research

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Background

Laser projection is regarded as the future technology for digital projection. To realise a full colour laser TV set according to the RGB concept an array of three laser types is thus required. For red and blue efficient laser diodes are already available. Since there are no efficient green emitting laser diodes commercially available yet, the conversion of the blue laser by a luminescent screen is still of interest.

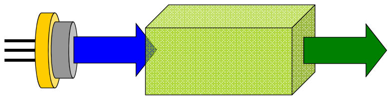

Fig. 1 Principle of light conversion

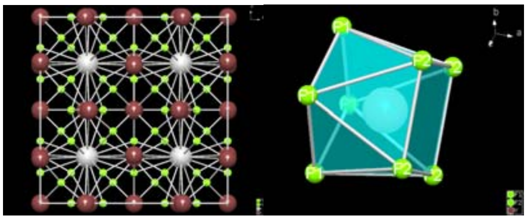

Fig. 2 Crystal structure of KY_3F_{10}

Converter materials for such a luminescent screen mostly rely on single crystalline bodies, also called laser crystals. An alternative material class is transparent ceramics, which are presently attracting more and more interest. They are less time consuming in preparation and offer a more homogeneous dopant distribution as single crystals. Moreover, size and geometry can be almost arbitrarily designed. Therefore, they are cheaper in production compared to single crystals. A severe problem of transparent ceramics is, however, scattering at grain boundaries and cavities. Consequently, a laser ceramic must have a low pore density, i.e. a density, which is close to the theoretical value, and an isotropic index of refraction.

In this study, the host lattice KY_3F_{10} was investigated. It exhibits a cubic crystal system (a = 11,543 Å), low phonon frequencies (approx. 420 cm^{-1}), and a wide band gap (10 eV), which are some of the most important requirements to a transparent laser material. The host lattice was doped by trivalent Praseodymium onto the Y^{3+} position as the active medium.

Synthesis

Powder preparation was performed by conventional solid state chemistry methods. As starting materials high purity KF, YF_3, and PrF_3 were used. Appropriate blends were sintered for 4 h at 650 °C in a Nitrogen stream to obtain single phase material. The fluorescence spectra show excitation lines in the blue spectral range and emission lines in the green and red spectral range due to the $[Xe]4f^2$ - $[Xe]4f^2$ transitions of trivalent Praseodymium. The mean particle size of the powder is 1 – 2 µm and forming agglomerates with a size of about 10 µm.

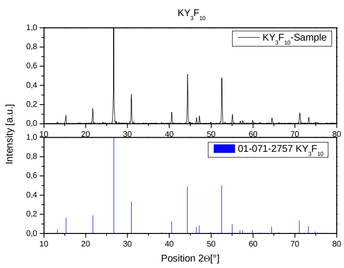

Fig. 3 Powder diffraction pattern of an as-prepared KY_3F_{10} sample

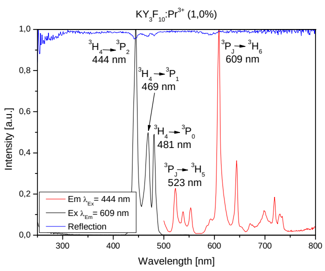

Fig. 4 Luminescence and reflection spectra of a $KY_3F_{10}:Pr^{3+}$ powder sample

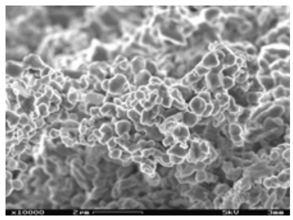

Fig. 5 SEM image of a KY_3F_{10} powder sample

Obtained powders were pressed firstly uniaxial and secondly isostatical for one hour to achieve pellets with a high green body density. These green bodies were subsequently sintered for several hours at 800 °C in a Nitrogen stream. The resulting translucent ceramics were characterized by optical spectroscopy.

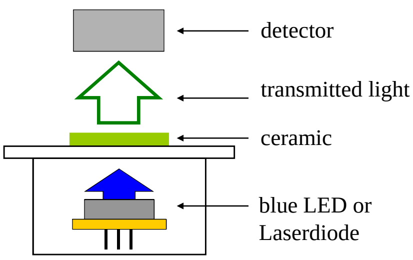

Fig. 6 Spectrometer set-up to record luminescence spectra in transmission mode

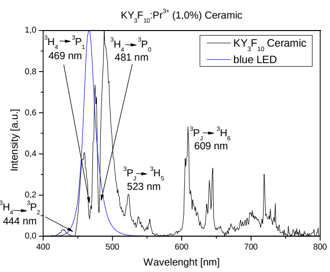

Fig. 7 Blue LED and resulting spectrum upon passing a $KY_3F_{10}:Pr^{3+}$ ceramic

Fig. 8 Example of a typical translucent $KY_3F_{10}:Pr^{3+}$ ceramic

Conclusions

Upon pressing the obtained powders uniaxially and isostatically, it is feasible to obtain green bodies with a density around 70 – 75% of the theoretical density. Sintering these green bodies yields densities up to 95%, which leads to translucent ceramics. The spectrum of a 465 nm LED measured in transmission through such a ceramic body consists of the blue LED spectrum modified by the absorption lines of Pr^{3+} and of the respective emission lines of Pr^{3+}.

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