Optical Properties of Translucent YAG/YAG:Ce Ceramics

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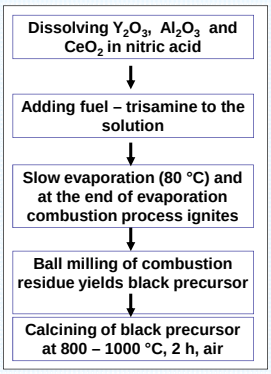
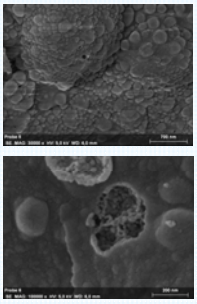
Luminescent screens are widely applied in fluorescent light sources in order to convert the radiation of the primary source into a spectrum suitable for the application aimed at. The screen is either a luminescent powder, eventually embedded into a polymer, a translucent ceramic or a single crystal, whereby the latter type is mainly used as a gain media in solid state lasers or as scintillators in CTs or PETs.
While luminescent powders and ceramics show strong scattering and thus solely limited transmission of the incident radiation, translucent ceramics and in particular single crystals show much less or almost no scattering.

Our experimental work thus focused on the development of translucent YAG:Ce (0.1 - 0.6%) and YAG ceramics, whereby the thickness and scattering properties are optimized to achieve white pcLEDs with an isotropic emission spectrum. The ceramics were made from a YAG/YAG:Ce precursor obtained from a combustion method by uniaxal and isostatic pressing with subsequent sintering at 1600 - 1700 °C.

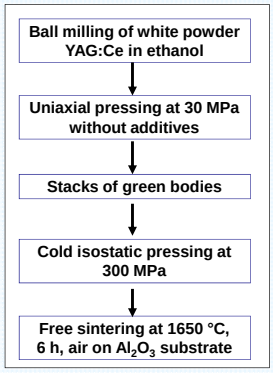
For the optimization of the package gain and spatial uniformity of the LED spectrum ceramic stacks comprising two ceramic layers, viz. one YAG and one YAG:Ce layer, were fabricated. The reflection, emission, and transmission spectra of these stacks as function of the orientation to the LED chip were recorded. From these results the optimal configuration with respect to orientation and layer thicknesses was derived. It was demonstrated that the scattering of blue light in the YAG layer has a strong impact on the overall spectrum achieved by the whole LED package.

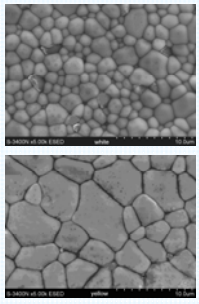
Powder Preparation, Ceramic Fabrication and Light Conversion of YAG:Ce^{3+} /YAG Sandwiches



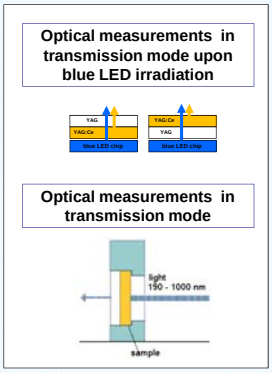


SEM images of calcined agglomerated precursor (YAG doped by 0,3% Ce)

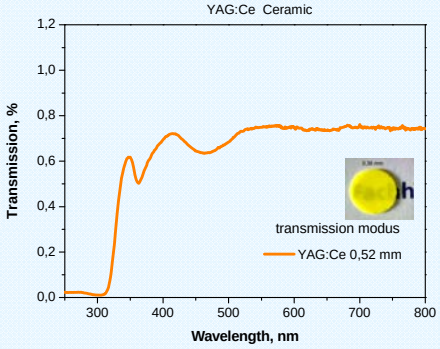


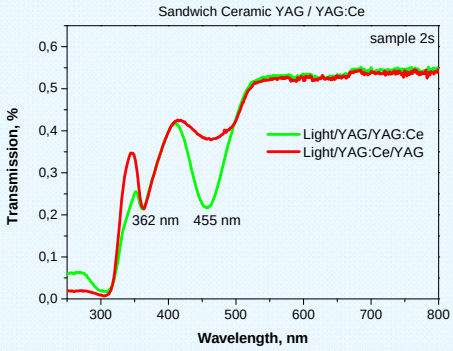


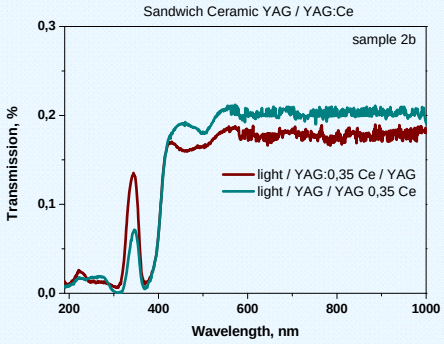
The surface of the ceramic sandwich: secondary electron imaging in the SEM: top – YAG, bottom – YAG:0,35 % Ce.



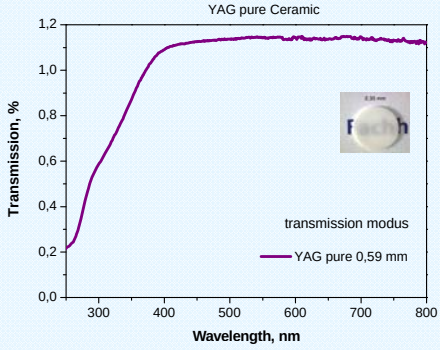
Transmission and Emission Spectroscopy of YAG:Ce^{3+}/YAG Sandwiches



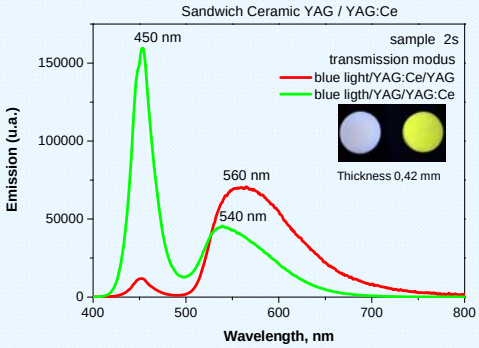


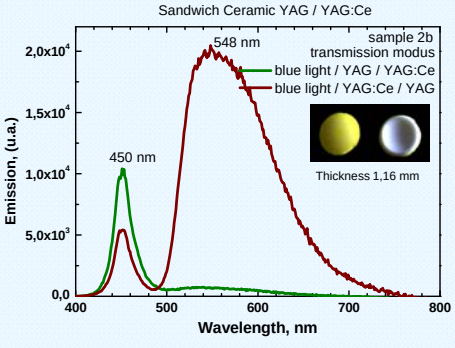


Transmission spectra of the sandwich YAG/YAG:Ce ceramics.



Transmission spectra of the mono-layer ceramics.





Transmitted emission spectra of the sandwich YAG/YAG:Ce ceramics measured under irradiation with the blue light - 450 nm.

Conclusions

If the undoped YAG layer of the YAG:Ce/YAG ceramic is faced towards the blue LED chip, the strong reflectance yields a spectrum which is perceived as cold white. The other orientation in contrast results in a warm white spectrum, since the blue light of the LED surpasses two times the YAG:Ce layer, viz. before and after its reflection at the undoped YAG layer. Therefore, a cold and warm white LEDs can be produced from one type of a YAG/YAG:Ce stack.