Green emitting $CdSiO_3$:Yb^{3+},Tb^{3+} materials: combining up-conversion and persistent luminescence

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Introduction

Up-conversion materials produce light or UV radiation under infrared excitation by converting, two or more low energy photons into one of higher energy. These materials receive special attention due to their potential applications to increase solar cell efficiency [1] and as biomarkers. Recently, persistent up-conversion luminescence was observed in ZrO_2:Yb^{3+},Er^{3+} materials for the first time [2] but, hitherto, it is the only report on this the new phenomenon. As a new approach to obtain persistent up-conversion luminescence materials, this work presents the preparation and up-conversion properties of the new $CdSiO_3$:Yb^{3+},Tb^{3+} material.

Results and Discusion

The $CdSiO_3$:Yb^{3+},Tb^{3+} materials were synthesized with a solid state reaction at 950 °C with Tb^{3+} and Yb^{3+} concentrations of 1 and 0.1 to 20 mol-% of the Cd amount, respectively. The XPD patterns (Fig. 1) confirm the presence of the monoclinic metasilicate ($CdSiO_3$) phase with the usual orthosilicate (Cd_2SiO_4) impurity. The materials with high (10 and 20 mol-%) Yb^{3+} concentrations also showed the presence of the $Yb_2Si_2O_7$ phase.

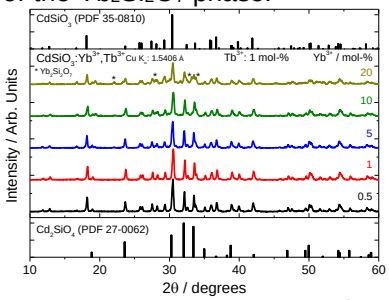

Figure 1. XPD patterns of $CdSiO_3$:Yb^{3+},Tb^{3+}.

The materials exhibit green persistent luminescence after UV (254 nm) irradiation, similar to that observed in $CdSiO_3$:Tb^{3+} [3]. However, no persistent luminescence is obtained after ceased IR irradiation. On the other hand, the material exhibits green up-conversion luminescence (Fig. 2) under 980 nm excitation. The up-conversion spectra are similar to the UV irradiated, except for the absence of the $^5D_3$ emission, indicating that the IR excitation populates mainly the $^5D_4$ emitting level. Since the $^5D_4$ level is below the conduction band of $CdSiO_3$ [3], trapping of electrons is not efficient, thus reducing the probability of persistent up-conversion luminescence in this material. An increase in the Yb^{3+} concentration leads to quenching of Tb^{3+} luminescence (Fig. 2, inset) probably due to segregation of the $Yb_2Si_2O_7$ phase which deprives Yb^{3+} concentration in $CdSiO_3$.

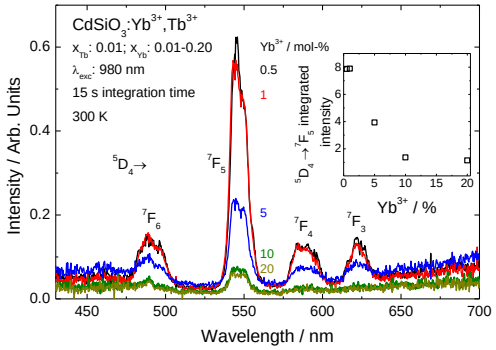

Figure 2. Up-conversion emission spectra of $CdSiO_3$:Yb^{3+},Tb^{3+}.

Conclusions

These results indicate that $CdSiO_3$:Yb^{3+},Tb^{3+} can be used as an optical marker yielding both persistent and up-conversion luminescence but not a combination of them. More studies are necessary to obtain new persistent up-conversion materials.

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