On the Efficiency of the Photon Cascade Phosphor $SrAl_{12}O_{19}:Pr^{3+}$

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Photon cascade processes offer the possibility to manufacture phosphor materials for fluorescence lighting with quantum efficiencies greater than 100%: - a quantum efficiency of 140% has been demonstrated in the GE laboratories for YF_3Pr^{3+} [1]. Pr^{3+} doped $SrAl_{12}O_{19}$ was expected to be another promising photon cascade phosphor, with a theoretical quantum efficiency of about 130 % under UV excitation [2]. Experimentally, however, a significantly lower quantum efficiency was found. We have performed extensive studies of this material to unravel the cause for the apparent luminescence quenching, including photoexcitation and time-resolved emission measurements at temperatures between 10 K and 450 K, as well as thermoluminescence studies to locate the ionization threshold of the Pr^{3+} ion. We find that the low quantum efficiency of $SrAl_{12}O_{19}:Pr^{3+}$ is not caused by thermal quenching, but results from the location of the Pr^{3+} energy levels relative to the host conduction band. Specifically, the Pr^{3+} 5d level is resonant with the host conduction band, which opens up non-radiative relaxation channels.
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References:

[1] W.W. Piper, J.A. DeLuca, and F.S. Ham; J. Lumin. 8 (1974) 344.

[2] A.M. Srivastava and W.W. Beers, J. Lumin. 71 (1997) 285.