Phase transitions modulating trap depth and mechanoluminescence in $Ca_{1-x}Sr_xAl_2Si_2O_8$: 1%Eu^{2+}, 1%Pr^{3+} phosphors

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$Ca_{(1-x)}Sr_xAl_2Si_2O_8$ displays two phase transitions, namely $P\bar{1}$ to $I\bar{1}$ and $I\bar{1}$ to I2/c, depending on chemical composition at ambient temperature and pressure. The first transition is due to structural relaxation[1], and the second is due to ferroelastic transitions where atomic occupancy at anionic tetrahedra switches from order to disorder[2]. The effects of both structural expansion and ordering of Al/Si at tetrahedral sites on luminescence, especially mechanoluminescence (ML), in this system is of great value. Our results show that the photoluminescence emission peak shifts to higher energy, but at a relatively smaller rate when x>0.7, where a transition to I2/c can be expected. A reduction of afterglow duration is also seen, with a faster rate starting from x~0.45, where the $P\bar{1}$ to $I\bar{1}$ may occur at ambient condition. ML intensity changes in this system in a non-linear manner, and a similar behavior was also reported before[3]. Thermoluminescence measurements reveal both the trap depth distribution and the ranges of trap depth active for mechanical stimuli as the composition is changed. The combined efforts suggest the interplay of these distributions of traps, which leads to the special trend of ML with respect to strontium content in this solid solution. This method also opens the door to understanding and tuning the property of mechanoluminescence.

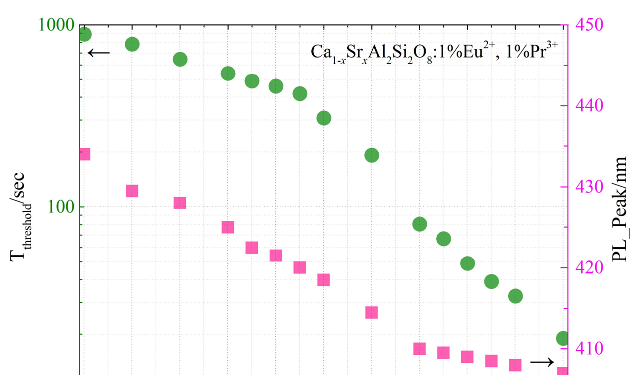

Figure 1. *The variation of PL emission peak (pink) and threshold time ($T_{threshold}$, green) of afterglow (above 0.32mCd/m^2) with strontium content x in the $Ca_{1-x}Sr_xAl_2Si_2O_8$:1%Eu^{2+},1%Pr^{3+} phosphors*

Reference:

1. M. Tribaudino, P. Benna and E. Bruno, *Am. Mineral.*, 2000, **85**, 963-970.
2. M. D. McGuinn and S. A. T. Redfern, *Am. Mineral.*, 1994, **79**, 24-30.
3. L. Zhang, C.-N. Xu, H. Yamada and N. Bu, *J. Electrochem. Soc.*, 2010, **157**, J50-J53.

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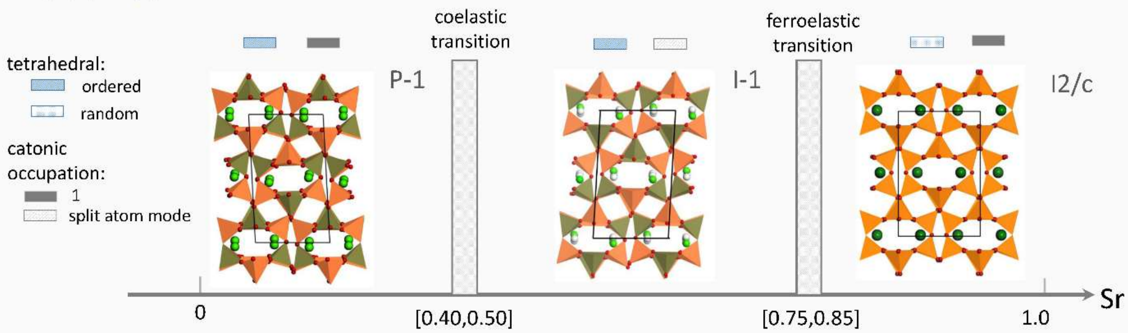
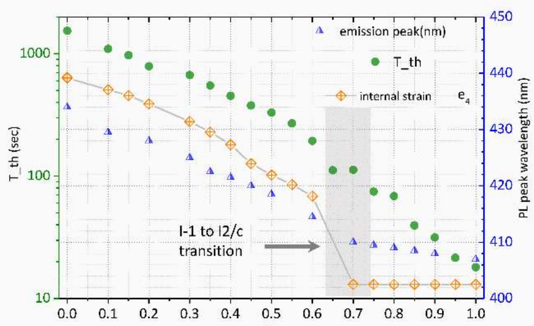
COMPOSITES

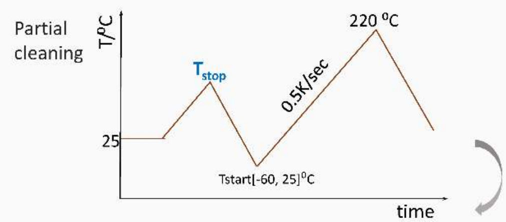
Initiatives

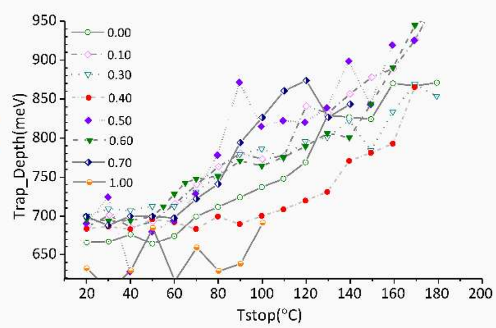


Question: How do phase transitions modulate traps and luminescence in this system?

Modulating trap depths and luminescence





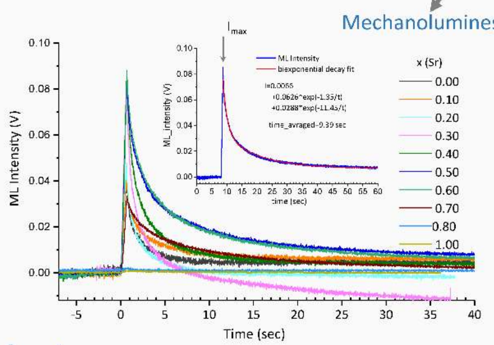


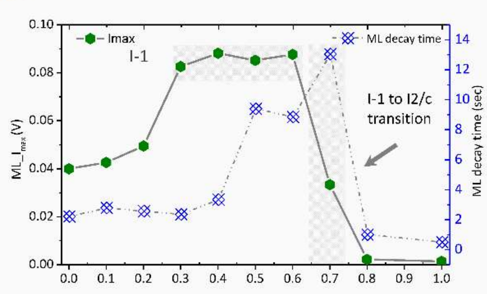
PL emission Afterglow

Trap depth distribution

Phase Transitions

Mechanoluminescence





Conclusions

- I-1 to I2/c transitions modulate PL emission, afterglow duration and trap depth distribution
- P-1 to I-1 and I-1 to I2/c transitions influence the ML intensity and ML decay time