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Mechanoluminescence of Europium-doped $SrAMgSi_2O_7$ (A=Ca, Sr, Ba)

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1. Introduction

Mechanoluminescence (ML) is the emission of phosphors caused by applying mechanical energy to a solid.[1] The ML sensor to detect environmental stress by emitting light can be used widely in various applications such as the forecasting of an earthquake, the damage detection of an air plane or car and the body disease of a human et al.[2] For these ML sensors, searching materials with high ML is an important work. The Xu lab has developed a serial of strong visible ML materials, for example, green phosphor $SrAl_2O_4$: Eu,[3] red phosphor $BaTiO_3$-$CaTiO_3$: Pr [4] and so on. In this work, we have synthesized three new ML materials $SrBaMgSi_2O_7$:Eu, (SBMSE), $Sr_2MgSi_2O_7$:Eu, (SMSE) and $SrCaMgSi_2O_7$:Eu, (SCMSE) , which can emit navy blue (440 nm), light blue (464 nm) and blue-greenish (499 nm) ML light.

2. Results and Discussion

Fig. 1 displays the XRD patterns of SBMSE, SMSE and SCMSE. $SrBaMgSi_2O_7$ and $SrCaMgSi_2O_7$ were not found in ICCD database. But compared with the standard patterns of $Sr_2MgSi_2O_7$ (JCPDS 75-1736), it could be seen that the major diffraction peaks of SBMSE and SCMSE are similar to those of SMSE. The result reveals that the samples SBMSE and SCMSE have the same crystal structure as $Sr_2MgSi_2O_7$, which have a tetragonal symmetry with space group P4 2_1m. In addition, the location of these diffraction peaks shifted towards low (SCMSE) or high angle (SBSE) compared with that of the corresponding peaks for $Sr_2MgSi_2O_7$, indicating that the change of alkaline earth ions induces a little effect on the structure of the sample.

Fig. 2 shows the PL and ML spectra of SBMSE, SMSE and SCMSE. Due to the existence of different alkaline earth ions, their emission wavelengths are different, located at 440 nm, 464 nm and 499 nm respectively. These emissions can be assigned to the $4f^7$-$4f^65d$ transitions of Eu^{2+} ions. At the same time, the ML spectra of these

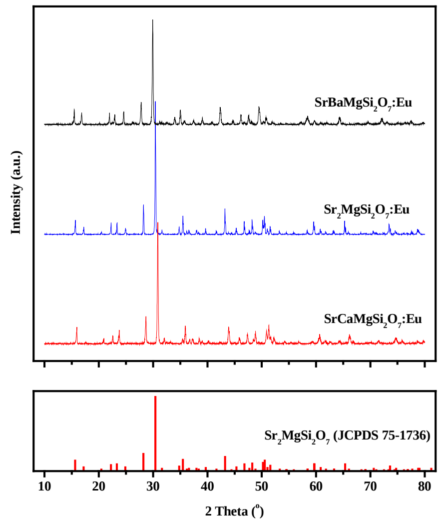

Fig. 1 XRD patterns of SBSE, SMSE and SCMSE

samples activated by 1000N compress were measured, as shown in Figure 2(b). it can be observed that the ML emission wavelengths are similar to the PL emission wavelengths, respectively. This result indicates that that the ML also originates from the same emitting center of Eu^{2+} ions and the transition of Eu^{2+} ions between $4f^7$ and $4f^65d$ state is responsible for these ML emissions.

Fig. 3 displays the comparison of ML intensities among SBMSE, SMSE and SCMSE samples. Compared with the other two phosphors, the blue phosphor SMSE possesses the strongest ML intensity. The ML intensity of SCMSE is slightly weak. While the ML intensity of

SBMSE is the weakest, only about 10% of that for SMSE. Furthermore, from this figure, it can be seen that the linearly increase of compressive load can induce the increase of ML intensity, which shows the excellent linear relation. That is, the ML intensity of SMSE is linearly proportional to the magnitude of the applied load. At the same time, it should be noted that the other two ML phosphors SBMSE and SCMSE also behave this property. Such ML properties of these phosphors can provide high sensitivity for smart-skin and self-diagnosis applications.

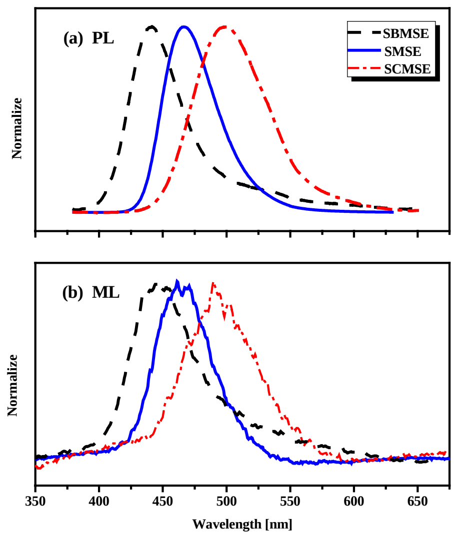

Fig. 2 PL and ML spectra of SBMSE, SMSE and SCMSE

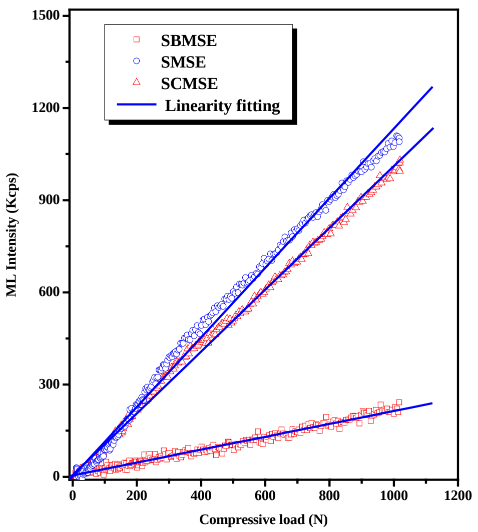

Fig. 3 Comparison of ML intensities for SBMSE, SMSE and SMSE samples

3. Conclusions

In summary, we studied the different color ML phosphor $SrAMgSi_2O_7$:Eu (A=Ba, Ca, Sr). The ML and PL spectra are similar, which reveals that ML is emitted from the same center of Eu^{2+} ions. When pressing these samples, navy blue (SBMSE), light blue (SMSE) and blue-greenish (SCMSE) lights of ML emission can be observed by the naked eye. It should be noted that the dependences between ML intensities and the loads are nearly close to linearity, which suggests that these phosphors can be used as sensors to detect the stress of an object.

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