Photoluminescence of Eu\textsuperscript{2+} Doped Silicates

F. Baur\textsuperscript{*} and T. Jüstel\textsuperscript{*}

\*Department of Chemical Engineering, Münster University of Applied Sciences, Stegerwaldstr. 39, D-48565 Steinfurt, Germany

Rare Earth Elements Conference 2012, September 04-06, Münster, Germany

Introduction

This work deals with an Eu\textsuperscript{2+} doped silicate, viz. BaMg\textsubscript{2}Al\textsubscript{6}Si\textsubscript{9}O\textsubscript{30}Eu\textsuperscript{2+}, which was prepared by a two-step high temperature solid state synthesis, and the characterization of its optical properties. From the XRD patterns it was assumed that all prepared samples were of single phase. The structure, as depicted in Fig. 2, is a cyclosilicate, consisting of layers of six-membered double-rings with the bigger cations located between the silicon layers. Fig. 4 exhibits the emission spectrum of a typical BaMg\textsubscript{2}Al\textsubscript{6}Si\textsubscript{9}O\textsubscript{30}Eu\textsuperscript{2+} sample is unusually broad, i.e. it consists of at least two overlapping bands. This implies that the Eu\textsuperscript{2+} ions occupy more than one site in the crystal structure of BaMg\textsubscript{2}Al\textsubscript{6}Si\textsubscript{9}O\textsubscript{30} since the 4f5d luminescence of Eu\textsuperscript{2+} can solely cause one emission band. However, according to Winter et al., there is only one crystallographic site for divalent barium in undoped BaMg\textsubscript{2}Al\textsubscript{6}Si\textsubscript{9}O\textsubscript{30}.\textsuperscript{[1]} The nature of the luminescence and the number of emitting sites will be discussed in the framework of the Eu\textsuperscript{2+} concentration and the presence of impurity phases.

Crystal Structure and XRD

![Crystal structure image](image1)

Results

Table 1. Decay times and Luminous Efficacies (LE).

<table>
<thead>
<tr>
<th>Conc. Eu\textsuperscript{2+}</th>
<th>Wavelength [nm]</th>
<th>Δt [µs]</th>
<th>τ [µs]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5% Eu\textsuperscript{2+}</td>
<td>377</td>
<td>0.86</td>
<td>1.13</td>
</tr>
<tr>
<td>1% Eu\textsuperscript{2+}</td>
<td>377</td>
<td>0.74</td>
<td>1.15</td>
</tr>
<tr>
<td>2% Eu\textsuperscript{2+}</td>
<td>377</td>
<td>0.66</td>
<td>1.20</td>
</tr>
<tr>
<td>5% Eu\textsuperscript{2+}</td>
<td>377</td>
<td>0.58</td>
<td>1.08</td>
</tr>
<tr>
<td>8% Eu\textsuperscript{2+}</td>
<td>377</td>
<td>0.50</td>
<td>1.00</td>
</tr>
</tbody>
</table>

![Normalized Intensity plot](image2)

![Normalized Intensity plot](image3)

![Normalized Intensity plot](image4)

![Normalized Intensity plot](image5)

![Normalized Intensity plot](image6)

![Normalized Intensity plot](image7)

![Normalized Intensity plot](image8)

![Normalized Intensity plot](image9)

![Normalized Intensity plot](image10)

Conclusions

- Single phase target materials can be prepared by calcining stoichiometric amounts of the respective oxides or carbonates at 700 °C for 2 h and then annealing at 1300 °C for 10 h in CO. At activator concentrations > 0.5% the material did melt during annealing. Lower temperatures were not sufficient to obtain single phase material.
- The optical band gap of BaMg\textsubscript{2}Al\textsubscript{6}Si\textsubscript{9}O\textsubscript{30} is about 250 nm (= 5.0 eV). The phosphor can be efficiently excited in the UV-B and UV-A spectral regions.
- The unusual emission spectrum can be explained by assuming two distinct crystallographic Eu\textsuperscript{2+} sites, substituting Ba\textsuperscript{2+} or Mg\textsuperscript{2+} in the host structure.\textsuperscript{[2]} The higher energy UV-A emission could stem from Eu\textsuperscript{2+} located at Ba\textsuperscript{2+} sites, while the lower energy blue emission could stem from Eu\textsuperscript{2+} located at Mg\textsuperscript{2+} due to a difference in crystal field strength.
- With increasing Eu\textsuperscript{2+} concentration the high energy emission decreases, while the lower energy emission increases in intensity. This might indicate a potential energy transfer between the two sites. This assumption agrees well with the decreasing decay time of the 376 nm emission and the constant decay time of the 450 nm emission (Fig. 5, Table 1).
- The change in the emission spectra is reflected in a change in color point and luminous efficacy (LE). High activator concentrations result in increased LE and a red-shift of the CP. This property of the material allows for a fine-tuning of the CP, making the phosphor an interesting choice for emissive displays.
- The quantum efficiency (QE) remains constant with increasing Eu\textsuperscript{2+} concentration up to 8%.
- The author would like to thank A. Katelnikovas for his valuable assistance in spectroscopy and discussion.