A Ceramic Version of the LSO Scintillator

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Motivation, LSO is ...

- Very successful scintillator for PET
  - good light output
  - fast
  - dense
- Difficult to grow (high m.p.)
- Not readily available
- Expensive
Ceramic process can produce material

- With similar properties
- At lower temperatures
- At lower cost

$\text{Al}_2\text{O}_3$, $\text{AlION}$, $\text{YAG}$, $\text{GOS}$, $\text{LuAG}$, $(\text{Gd/Y})_2\text{O}_3$
**LSO - Lu$_2$OSiO$_4$**

<table>
<thead>
<tr>
<th></th>
<th>Ceramic</th>
<th>Crystal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light output</td>
<td>21,000 ph/MeV</td>
<td>35,000 ph/MeV</td>
</tr>
<tr>
<td>Decay time</td>
<td>~34 ns</td>
<td>~40 ns</td>
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<tr>
<td>Rise time</td>
<td>~0.3 ns</td>
<td>~0.5 ns</td>
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<tr>
<td>Emission</td>
<td>430 nm</td>
<td>420 nm</td>
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</tbody>
</table>
Preparation

- **Hot pressing**
  - 1300-1700 °C
  - Vacuum
  - 8000 psi

- **Bleaching**
  - 1000-1300 °C
  - Air
Ceramic Sample

1mm thick × 15mm diameter

sample resting on a light box
$^{137}\text{Cs} \text{ Energy Spectra}$

$\sim 58\%$ of the LSO crystal

$^{137}\text{Cs} \text{ Spectra}$

![Graph depicting $^{137}\text{Cs}$ energy spectra with peaks at 425 and 731 MCA channels.](www.alemassociates.com)
Bleaching – It does help …

Light output improves ~8 times!

LSO:Ce

$^{137}$Cs Spectra

bleaching

before

after

Www.alemassociates.com
Emission

LSO:Ce

- ceramic
- powder
- crystal

intensity, arb. units vs. wavelength, nm
Bleaching - Emission

Integrals:

- 8534
- 7462
- 5470
- 1832

Bleaching Steps:
- 1050 C
- 1150 C
- 1250 C

None
Time Profile 1

Crystal
40 ns

Ceramic
Untreated
26 ns

Bleached
34 ns

Normalized Intensity vs. Time (nanoseconds)

Crystal
$\tau = 40.0 \text{ ns (100\%)}$

Ceramic (annealed)
$\tau = 6.5 \text{ ns (23.0\%), 34 ns (77.0\%)}$

Ceramic (untreated)
$\tau = 6.0 \text{ ns (30.6\%), 26 ns (68.4\%)}$

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Time Profile 2

- **Powder**: 40 ns
- **Ceramic**: 34 ns

Quenching?
Thermoluminescence

Intensity, counts/sec

Temperature, K

Unbleached

Bleached

LSO:Ce ceramic

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Afterglow

Ex.: 6 seconds @ 2.2 R/s

Normalized Intensity vs. Time (milliseconds)

- Ceramic
- Crystal
Conclusions

- **LSO Ceramic is possible**
  - Good light output
  - Fast decay
  - Dense

- **Work to be done:**
  - Translucency
  - Light output
The End.

More on Ceramic LSO at 2007 IEEE NSS/ MIC, Hawaii

Thank you for your attention.