ISMA NAS of Ukraine

Scintillation crystals of rare earth aluminates grown under reducing conditions.

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Crystals of rare earth aluminates are widely used in instrumentation.

Undoped YAG - as optical element.

YAG and LuAG activated with rare earth elements are used as laser and scintillation material, YAG:Ce as a phosphor in LED.
Czochralski growth from Ir crucible and its deformation.

Ir replacement – molybdenum (Mo), tungsten (W), and their alloys.

Benefits:
Temperature resistance.
Workability.
Cost – thousand times cheaper.
Durability.

Disadvantages:
More intense oxidation at high temperatures.
Interaction with melt components.

Protective atmosphere:
Carbon monoxide: (CO)  Hydrogen: H2  Their mix: (CO)+H2

The use of carbon insulation provides a good thermal insulation and causes the reducing conditions

\[ \text{Ar}(>99\%) + \text{C} + \text{O} \Rightarrow \text{Ar} + (<1\%)\text{CO} \]
### Peculiarities of undoped YAG crystals grown under weak oxidizing and reducing atmosphere.

<table>
<thead>
<tr>
<th>Raw material, synthesis condition.</th>
<th>Growth conditions</th>
<th>View of as - grown crystals.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powder of Al₂O₃ &amp; Y₂O₃, sintered under weakly-oxidizing atmosphere under 1600 °C.</td>
<td>Ir crucible, weakly oxidizing atmosphere.</td>
<td>YAG 1 (Ir)</td>
</tr>
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<td>Powder of Al₂O₃ &amp; Y₂O₃, sintered under weakly oxidizing atmosphere under 1600 °C.</td>
<td>W crucible, weakly reducing atmosphere, melt preparation time &lt; 2 h.</td>
<td>YAG 2(W)</td>
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<tr>
<td>Powder of Al₂O₃ &amp; Y₂O₃, sintered under weakly oxidizing atmosphere under 1600 °C.</td>
<td>W crucible, weakly reducing atmosphere, melt preparation time &lt; 30 h.</td>
<td>YAG 3 (W)</td>
</tr>
<tr>
<td>YAG 3 crystal.</td>
<td>Ir crucible, weakly oxidizing atmosphere.</td>
<td>YAG 4 (Ir,W)</td>
</tr>
</tbody>
</table>
As grown YAG absorption spectra.
Impact of post growth annealing under oxidizing and reducing atmospheres.

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<tr>
<th></th>
<th>As-grown</th>
<th>Air 1200 ºC, 5 ч</th>
<th>Ar+CO, 1800 ºC, 30 min</th>
</tr>
</thead>
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<tr>
<td>YAG 1 (Ir)</td>
<td><img src="YAG1Ir.png" alt="Image" /></td>
<td><img src="YAG1IrAir1200.png" alt="Image" /></td>
<td><img src="YAG1IrArCO1800.png" alt="Image" /></td>
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<td>YAG 2 (W)</td>
<td><img src="YAG2W.png" alt="Image" /></td>
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Absorption spectra of YAG 1–4 annealed under oxidizing and reducing atmospheres.

Air treatment 5 h, 1200 °C.

Reducing atmosphere treatment 30 min, 1800 °C.
X–ray and photoluminescence of YAG(W) crystals.

Photoluminescence of YAG(W) crystals, under 405 nm excitation.

X–ray luminescence of YAG(W) crystals.
Obtaining of undoped LuAG crystals from W crucible under reducing atmosphere.

As-grown LuAG (W) crystal. As-grown LuAG (W) sample.

Influence of treatment under reducing atmosphere on coloration of LuAG crystals grown from Ir or W crucible.

LuAG (Ir) sample Ht CO. LuAG (W) sample Ht CO.
Obtaining of YAG:Ce crystals from W crucible under reducing atmosphere.

Absorption spectra of YAG:Ce crystals, as-grown and treated under oxidative and reducing atmospheres.

X-ray luminescence of as grown YAG:Ce crystals.
Conclusions.

1. Ir crucibles could be replaced by cheaper W crucibles in case of obtaining rare earth aluminates, such as YAG, LuAG, YAG:Ce. Carbon admixture introduces into the crystal, but its position in the lattice is unknown.

2. Post growth thermal treatment is a key factor to obtain optical and scintillation parameters comparable to crystals grown from Ir crucibles.
Acknowledgements

The work is partially supported by:

- Marie Skłodowska-Curie Research, Innovation Staff Exchange Project H2020-MSCA-RISE-2014 No. 644260 “Intelum”

- Ukrainian-French PICS project between CNRS (Project no.6598) and National Academy of Sciences of Ukraine (Project F1-2016)
Thank you!
Obtaining of pure CeAlO$_3$ (CAP) crystals from W crucible in reducing atmosphere.

Absorption spectra of CAP (W) crystals treated in CO under 1300 °C 1 h.