# List of cubic samples received on 22/02/16

<table>
<thead>
<tr>
<th>ID Cern</th>
<th>Dimensions [mm]</th>
<th>Ce concentration [%]</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>3099</td>
<td>$10 \times 10 \times 10$</td>
<td>1</td>
<td>Pb doped</td>
</tr>
<tr>
<td>3100</td>
<td>$10 \times 10 \times 10$</td>
<td>1</td>
<td>Pb doped</td>
</tr>
<tr>
<td>3101</td>
<td>$10 \times 10 \times 10$</td>
<td>1</td>
<td>Pb doped</td>
</tr>
<tr>
<td>3102</td>
<td>$10 \times 10 \times 10$</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>3103</td>
<td>$10 \times 10 \times 10$</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>3104</td>
<td>$10 \times 10 \times 10$</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>3105</td>
<td>$10 \times 10 \times 10$</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td>3106</td>
<td>$10 \times 10 \times 10$</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td>3107</td>
<td>$10 \times 10 \times 10$</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td>3108</td>
<td>$10 \times 10 \times 10$</td>
<td>0</td>
<td>undoped</td>
</tr>
<tr>
<td>3109</td>
<td>$10 \times 10 \times 10$</td>
<td>0</td>
<td>undoped</td>
</tr>
<tr>
<td>3110</td>
<td>$10 \times 10 \times 10$</td>
<td>0</td>
<td>undoped</td>
</tr>
<tr>
<td>3111</td>
<td>$10 \times 10 \times 10$</td>
<td>0</td>
<td>undoped</td>
</tr>
</tbody>
</table>
AFO:Ce (1%) - Pb doped
Transmission Curves

- Good transmission of all samples (with some spread)
- Band edge around 340 nm
Photoluminescence spectra

- Excitation in UV region with peaks at 250 and 330 nm
- Emission peak around 375 nm
Decay time - AFO Pb

- Measurement of decay time using single photon counting technique (see Bollinger and Thomas [1])
- Instrumental response has been subtracted
- Cherenkov light is dominating
- A fast scintillation component (∼ 10 ns) seems to exist
AFO:Ce (1%)
Transmission Curves

- Good transmission of all samples (with small spread)
- Band edge around 340 nm
Photoluminescence spectra

- Excitation in UV region with peak at 330 nm (no peak at 250 nm)
- Emission peak around 370 nm
Decay time - AFO Ce 1%

- Measurement of decay time using single photon counting technique (see Bollinger and Thomas [1])
- Instrumental response has been subtracted
- The main decay component is around 50 ns
- A faster component (probably cherenkov or intrinsic) is also observed
AFO:Ce (0.5%)
Transmission Curves

- Good transmission of all samples (with some spread)
- Band edge around 340 nm
- It seems there is some absorption peak at 270 nm
Photoluminescence spectra

- Excitation in UV region with peaks at 250 and 330 nm
- Emission peak around 370 nm
Decay time - AFO Ce 0.5%

- Measurement of decay time using single photon counting technique (see Bollinger and Thomas [1])
- Instrumental response has been subtracted
- The main decay component is around 48 ns
- A faster component (probably cherenkov or intrinsic) is also observed

\[
\begin{align*}
\tau_1 &= 5.7353 \text{ ns} - I_1 = 0.0168221 \\
\tau_2 &= 48.3306 \text{ ns} - I_2 = 0.983178
\end{align*}
\]
AFO:Ce (0%) - undoped
Transmission Curves

- Good transmission of all samples (with some spread)
- Band edge around 340 nm
Photoluminescence spectra

- Excitation in UV region with peak at 270 nm
- Emission peak around 330 nm
Decay time - AFO undoped

- Measurement of decay time using single photon counting technique (see Bollinger and Thomas [1])
- Instrumental response has been subtracted
- Mostly one fast component (probably cherenkov or intrinsic) is observed

![Graph showing decay time and normalized intensity for AFO undoped.]

\[ \tau_1 = 0.730339 \text{ ns} - I_1 = 0.287644 \]
\[ \tau_2 = 173.995 \text{ ns} - I_2 = 0.712356 \]
Comparison between samples
Transmission Curves

- Good transmission of all samples above band edge
- Undoped sample has better transmission in the UV as expected
Photoluminescence spectra

- Pb doping causes change in the excitation band (peak at 250 nm)
- Undoped glass shows an (intrinsic?) emission and excitation in a more UV region than other glasses
Light yield spectra

- Measurement of light yield using $^{137}$Cs source (662 keV)
- Samples were wrapped with Teflon and coupled with grease ($n = 1.41$) to the PMT window

- PMT quantum efficiency is 24.5% for AFO:Ce (Pb) and 20.8% for AFO undoped
- Sample AFO with 1% Ce has higher light output than 0.5%
- Pb doped sample has slightly lower light output than undoped one!
Conclusions
<table>
<thead>
<tr>
<th>ID Cern</th>
<th>AFO type</th>
<th>Emission [nm]</th>
<th>Decay time [ns]</th>
<th>Light yield [ph/MeV]</th>
<th>$\rho$ [g/cm$^3$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>3099</td>
<td>1% Ce + Pb doped</td>
<td>375</td>
<td>-</td>
<td>&lt; 80</td>
<td>4.6</td>
</tr>
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<td>1% Ce + Pb doped</td>
<td>375</td>
<td>-</td>
<td>&lt; 80</td>
<td>4.6</td>
</tr>
<tr>
<td>3102</td>
<td>1% Ce</td>
<td>370</td>
<td>50 ± 5</td>
<td>~ 310</td>
<td>4.1</td>
</tr>
<tr>
<td>3103</td>
<td>1% Ce</td>
<td>370</td>
<td>50 ± 5</td>
<td>~ 310</td>
<td>4.1</td>
</tr>
<tr>
<td>3104</td>
<td>1% Ce</td>
<td>370</td>
<td>50 ± 5</td>
<td>~ 310</td>
<td>4.1</td>
</tr>
<tr>
<td>3105</td>
<td>0.5% Ce</td>
<td>370</td>
<td>48 ± 5</td>
<td>~ 170</td>
<td>4.1</td>
</tr>
<tr>
<td>3106</td>
<td>0.5% Ce</td>
<td>370</td>
<td>48 ± 5</td>
<td>~ 170</td>
<td>4.1</td>
</tr>
<tr>
<td>3107</td>
<td>0.5% Ce</td>
<td>370</td>
<td>48 ± 5</td>
<td>~ 170</td>
<td>4.1</td>
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<tr>
<td>3108</td>
<td>0% Ce</td>
<td>330</td>
<td>-</td>
<td>&lt; 120</td>
<td>4.1</td>
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<tr>
<td>3109</td>
<td>0% Ce</td>
<td>330</td>
<td>-</td>
<td>&lt; 120</td>
<td>4.1</td>
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<tr>
<td>3110</td>
<td>0% Ce</td>
<td>330</td>
<td>-</td>
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<td>-</td>
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</tbody>
</table>
Conclusions

Summary:

▶ All samples show a good optical quality (transmission)
▶ Undoped samples show intrinsic scintillation properties with different emission and excitation wavelengths but low light yield
▶ The highest light yield is measured for the AFO:Ce (1%) samples but remains below 320 ph/MeV
▶ Pb co-doped samples have a very poor light output
▶ Decay time is measured for AFO:Ce (1%) and AFO:Ce (0.5%) and is about 50 ns
▶ For all samples a low intensity fast component (probably cherenkov or intrinsic) is observed
▶ Results obtained on the AFO:Ce (1%) samples are consistent with previously measured AFO:Ce (1%) #3092
▶ Next step will be irradiation with $\gamma$-rays