Update of SEASON project

Spectroscopy Electron Alpha in Silicon

Box counter

Marine VANDEBROUCK

GCM2022 Workshop
October 2022
SEASON at S³-LEB

- **SEASON** will be mounted at the end of the S³-LEB for the study of HN/SHN

- It will be dedicated to:
  1. Counting laser ionized at atoms (laser ionization spectroscopy)
  2. $\alpha$, electron, $\gamma$ decay spectroscopy

⇒ Coupling atomic and nuclear approaches to study HN/SHN produced at S³
What is SEASON?

2 Ge detectors
EXOGAM

2 Si detectors
Long $T_{1/2}$ station

5 Si detectors
Main station

11 Implantation foils

Wheel
2 mm thick – 35 cm $\odot$

Laser ionized atoms
3 - 30 keV

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GCM2022
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Laser ionized atoms
3 - 30 keV
Goal 1: counting the laser ionized atoms to perform laser ionization spectroscopy

- Need good detection efficiency for $\alpha$ (5 – 12 MeV) and electrons (20 – 600 keV)

Tunnel configuration
Si detectors (BB7 from Micron)
- Thickness 1 mm
- Active area 64 x 64 mm$^2$

- Simulations (NPTOOL) in compact configuration:
  - $\alpha$ detection efficiency 81%
  - electron detection efficiency 51%

R. Ferrer et al., PLB 728(2014)
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- Thickness: 1 mm
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- Simulations (NPTOOL) in compact configuration:
  - $\alpha$ detection efficiency: 81%
  - Electron detection efficiency: 51%

Goal 2: perform $\alpha$, electron, $\gamma$ decay spectroscopy

- Need good energy resolution and avoid summing effects

<table>
<thead>
<tr>
<th>Energy resolution (FWHM)</th>
<th>15 keV ($\alpha$ from 5 MeV to 12 MeV)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 keV (electron from 20 keV to 600 keV)</td>
</tr>
<tr>
<td>Energy threshold</td>
<td>20 keV</td>
</tr>
<tr>
<td>Time resolution (FWHM)</td>
<td>20 ns</td>
</tr>
</tbody>
</table>

Si detectors (BB7 from Micron)
- Thickness: 1 mm
- Active area: 64 x 64 mm$^2$
- Number of strips: 32 x 32
- Strip pitch: 2 mm
- Dead layer: 50 nm
• Test of the SEASON DSSD prototype
  Work of Damien THISSE (postdoc)

• Implantation foils

• Mechanics
Test of the SEASON DSSD prototype

Si detector

Front-End Adaptive gain Integrated Circuits is a novel multi-channel ASIC in development at CEA/IRFU

Front-End

BACK- END

2 gains (2 energy ranges) depending of the signal height

High gain 50 fF
Low gain 550 fF

electron
alpha

NUMEXO2
Test of the SEASON DSSD prototype

Source 3α – Fixed low gain 550 fF

![Graph showing energy distribution and FWHM values for different voltages.](image)
Test of the SEASON DSSD prototype

Source 3α – Fixed low gain 550 fF

- Energy [A.U]
- Counts vs. Energy

Source 133Ba – Fixed high gain 50 fF

- 10.1 keV FWHM
- 11.2 keV FWHM
- 9.7 keV FWHM
- 11.1 keV FWHM

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Test of the SEASON DSSD prototype

Source 3α – Fixed low gain 550 fF

- Energy [A.U]
- Close to wanted performances with room for improvement (ex: dead layer)

Source 133Ba – Fixed high gain 50 fF

- 10,1 keV FWHM
- 11,2 keV FWHM
- 9,7 keV FWHM
- 11,1 keV FWHM

- Ongoing tests with the adaptive gain
• Test of the SEASON DSSD prototype

• Implantation foils
  Work of Emmanuel REY-HERME (PhD student)

• Mechanics
**Implantation foils**

**Option 1:** Carbon foils ~ 20 $\mu\text{g/cm}^2$ (90 nm)

**Option 1.1:** homemade C foils

Made at GANIL thanks to the help of G. Fremont

**Option 1.2:** Purchased from ACF metals C foils

The carbon foils are received on their glass plate
Implantation foils

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  The carbon foils are received on their glass plate

**Option 2:** SiN foils ~ 15 µg/cm² (50 nm) or ~ 9 µg/cm² (30 nm)

Purchased 4 foils from the SILSON company (2 X 30 nm and 2 X 50 nm)
Implantation foils

- Test bench at CEA Irfu/DEDIP (also used for FASLTAFF)

<table>
<thead>
<tr>
<th>Foil</th>
<th>Nominal thickness (µg/cm²)</th>
<th>Measured thickness (µg/cm²)</th>
<th>Stragglng (keV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon (GANIL)</td>
<td>~ 20</td>
<td>20 - 36</td>
<td>9 - 14</td>
</tr>
<tr>
<td>Carbon (ACF metal)</td>
<td>20(2)</td>
<td>19(1)</td>
<td>9</td>
</tr>
<tr>
<td>SiN (MICRON)</td>
<td>15(2)</td>
<td>12(1)</td>
<td>7</td>
</tr>
</tbody>
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Deviation observed for SiN foils
Implantation foils

- Test bench at CEA Irfu/DEDIP (also used for FASLTAFF)

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<th>Foil</th>
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Deviation observed for SiN foils

- Transmission Electron Microscopy (TEM) @JANNuS facility at IJCLab

- Diffraction measurement $\Rightarrow$ No crystalline structure/amorphous
- X-ray study $\Rightarrow$ Silicon and Nitrogen with a stochiometry ~ 1/1

<table>
<thead>
<tr>
<th>Element</th>
<th>Z</th>
<th>$p_m$ (%)</th>
<th>$p_A$ (%)</th>
</tr>
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<tr>
<td>Nitrogen</td>
<td>7</td>
<td>34.08</td>
<td>50.40</td>
</tr>
<tr>
<td>Silicon</td>
<td>14</td>
<td>63.12</td>
<td>46.56</td>
</tr>
<tr>
<td>Oxygen</td>
<td>8</td>
<td>1.87</td>
<td>2.42</td>
</tr>
<tr>
<td>Aluminium</td>
<td>13</td>
<td>0.44</td>
<td>0.34</td>
</tr>
<tr>
<td>Chlorine</td>
<td>17</td>
<td>0.49</td>
<td>0.29</td>
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- Electron Energy Loss Spectroscopy $\Rightarrow$ Measured thickness 13(1) $\mu$g/cm$^2$
Implantation foils

**Option 1:** Carbon foils ~ 20 µg/cm² (90 nm)

**Option 1.1:** homemade C foils
- Easy to make, not expensive
- Problem of repeatability, fragile

**Option 1.2:** Purchased from ACF metals C foils
- Easy to make, not expensive (~ 15 €/foil)
- Fragile

**Option 2:** SiN foils ~ 15 µg/cm² (50 nm) or ~ 9 µg/cm² (30 nm)
- Robust
- Expensive (~ 200 €/foil), support is imposed
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Selected option for SEASON
• Test of the SEASON DSSD prototype

• Implantation foils

• Mechanics
  Design at CEA Irfu/DIS
Mechanics

Wheel

Downstream Si detectors (Main and long T_{1/2} stations)

Upstream Si detectors (Main and long T_{1/2} stations)
Conclusion

- Detector and electronics have been validated
- Study of the implantation foils allowed to choose the material
- Design is finished, several elements have already been ordered
- First SEASON detector has been ordered and should be received in few weeks
Collaboration

Florent Bouyjou, Sandrine Cazaux, Thomas Chaminade, Olivier Cloué, Philippe Daniel-Thomas, Antoine Drouart, Alexis Gaget, Olivier Gevin, Thomas Goigoux (postdoc), Jean-Christophe Guillard, Hervé Le Provost, Jorge Mendes-Ribeiro, Gilles Minier, Julien Noury, Yann Reinert, Johan Relland, Emmanuel Rey-Herme (PhD student), Arnaud Roger, Barbara Sulignano, Christophe Theisen, Damien Thisse, Marine Vandebrouck

Thank you!