Optical Diagnostics

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BNL
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Optical Diagnostics

- tight environment
- high radiation area
- non-serviceable area
- passive components
- optics only, no active electronics
- transmit image through flexible fiber bundle
Optical Diagnostics

retroreflected illumination

Spherical mirror

laser illumination

image collection

cm scale

test target

Works OK in this tight environment
Optical Diagnostics

optical design in secondary containment

One set of optics per viewport

Conceptual design completed
Sumitomo imaging fibers – *used in our setup*

### Product Lineup

<table>
<thead>
<tr>
<th>Core material</th>
<th>IGN-02/03</th>
<th>IGN-028/06</th>
<th>IGN-035/06</th>
<th>IGN-037/03</th>
<th>IGN-05/10</th>
<th>IGN-08/030</th>
<th>IGN-15/030</th>
<th>IGN-20/50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cladding material</td>
<td>F Containing Silica</td>
<td>Pure Silica</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coating material</td>
<td>Silicone</td>
<td>Silicone + PFA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numerical aperture</td>
<td>0.35</td>
<td>0.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lattice defect (%)</td>
<td>&lt;= 0.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allowable bending radius (mm)</td>
<td>10</td>
<td>15</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>40</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>Allowable max temp. (°C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>150</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Cost

- **Cost per foot**:
  - IGN-02/03: $78
  - IGN-028/06: $158
  - IGN-035/06: $305
- **Cost in 10 meter**:
  - IGN-02/03: $2574
  - IGN-028/06: $5214
  - IGN-035/06: $10065
- **Total cost for 4 fibers (40 meter)**:
  - IGN-02/03: $10.3k
  - IGN-028/06: $20.8k
  - IGN-035/06: $40.3k

- Rad-hard to 1 Mrad

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IGN-08/30 sample
- 0.3-meter
- 30,000 pixels

Facet #1

50x

800x
Fujikura imaging fibers – Not used

Fujikura data, FIGH-30
A continuous 20-meter fiber
30,000 pixel imaging fiber

**Table 3**

<table>
<thead>
<tr>
<th>Item</th>
<th>FIGH-30-850N</th>
<th>FIGH-50-1100N</th>
<th>FIGH-70-1300N</th>
<th>FIGH-100-1500N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of picture elements (nominal)</td>
<td>30,000</td>
<td>50,000</td>
<td>70,000</td>
<td>100,000</td>
</tr>
<tr>
<td>Imagecircle diameter (um)</td>
<td>790 ± 50</td>
<td>1,025 ± 80</td>
<td>1,200 ± 100</td>
<td>1,400 ± 120</td>
</tr>
<tr>
<td>Fiber diameter (um)</td>
<td>850 ± 50</td>
<td>1,100 ± 80</td>
<td>1,300 ± 100</td>
<td>1,500 ± 120</td>
</tr>
<tr>
<td>Coating diameter (um)</td>
<td>950 ± 50</td>
<td>1,200 ± 100</td>
<td>1,450 ± 100</td>
<td>1,700 ± 150</td>
</tr>
<tr>
<td>Minimum bending radius (mm)</td>
<td>90°</td>
<td>110°</td>
<td>150°</td>
<td>200°</td>
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<tr>
<td>Coating material</td>
<td>Silicone resin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lattice defect (%)</td>
<td>&lt; 0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncircularity (%)</td>
<td>&lt; 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length/pc</td>
<td>Maximum length of 1pc : 10ft</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut and rough polish are available.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut length of 1pc : Customer order</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cost per foot | $85 | $250 | $540 |
Cost in 10 meter | $2805 | $8250 | $17.8k |
Total cost for 4 fibers (40 meter) | $11.2k | $33k | $71.8k |

unofficial price info

**official price info**

<table>
<thead>
<tr>
<th></th>
<th>Cost/foot</th>
<th>Cost in 10 meter</th>
<th>Cost in 20 meter</th>
<th>Total cost for 4 fibers (40 meter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$210</td>
<td>$6,935.65</td>
<td>$15,607.9</td>
<td>$27,742.6</td>
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<tr>
<td>2</td>
<td>$371.4</td>
<td>$12,256.7</td>
<td>$49,026.8</td>
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</tbody>
</table>
Image quality comparison

25 cm long

Fujikura
FIGH-30-850N
$210/foot delivery in 3 months

30,000 pixels, 1-mm diameter

Sumitomo
IGN-08/30
$78/foot delivery in 4 weeks

30 cm long

camera SMD illumination
NIR pulse, 10 us/frame

NO significant difference in image quality
Should go with Sumitomo fibers
(20 meters have been ordered)
All-in-one optical setup

Grin objective lens
imaging fiber – 1 mm
illumination fiber
fiber holder
Sumitomo IGN08/30 imaging fiber – 20-meter long

50 x

NIR 100 µs/frame static image

800 x
New baseplate on mock-up – SMD camera

SMD camera: NIR pulse 100 µs/frame
New baseplate on mock-up – FastVision camera

FastVision camera: NIR pulse 2 ms/frame
Summary

- 10-meter imaging fibers will be assembled on mock-up primary
- dynamic image collection on both viewports will be tested
- 1\textsuperscript{st} camera will be SMD CCD
- 2\textsuperscript{nd} camera will be FastVision CCD
- 2 sets of viewport/optics/CCD will be ready by the end of August
- 3 more 10-meter long imaging fibers in order – viewports 3\textsuperscript{rd} & 4\textsuperscript{th}