The real vacuum housing technology

of the Complete Modules leads to a completely controllable, hermetically sealed package. The vacuum tight metallic sealing prevents humidity penetration into the module and heat convection from cooled chip to the window. Results are higher reliability, reduced power loss by peltier cooling and further improved energy resolution.

Internal pressure and temperature sensors

allow the monitoring of the module vacuum. Vacuum values in the optimized range give best performance and reliability.

Vacuum held by reactivatable getter.

The internal getter keeps the pressure of a new module below 0.001 mbar. Though the hermetic sealing has been performed in an optimal way, over its lifetime, the getter surface can become covered with outgassing residues from housing materials or unavoidable leakages. The getter loses functionality, causing the inner module pressure to rise, and over several years, the module will act like a conventional module.

To prevent this, the vacuum of the Complete Module can be refreshed by reactivation of the getter.

Best chip performance combined with real vacuum housing

SDD chips with integrated FET from PNDetector's production allow us to offer Silicon Drift Detectors with well known spectroscopic performance, excellent energy resolution at moderate operation temperatures and short shaping times.
Completely Controlled Vacuum Details

Real vacuum housing with metallic lid-sealing, adapted glass pin insulation as well as vacuum proved housing materials, result in leakage / outgassing rates less than $1 \times 10^{-10}$ mbar l / s (see fig. 1).

It would take more than 10 years to reach a pressure of 20 mbar of a standard $\text{N}_2$ filled module even if no getter is activated.

Modern non-evaporable getter techniques reduce the pressure increase in a typical complete module to $1 \times 10^{-13}$ mbar l / s or 0.0002 mbar per month as long as the getter is active. This keeps the pressure inside the module at a starting value of 0.001 mbar, and it stays less than 0.01 mbar for more than a year.

The integrated pressure sensor allows measurement of the pressure inside the module. It works based on a Pirani principle and is used like a resistive voltage divider. Each Complete Module will be provided with an individual calibration curve (see fig. 2). Together with the on-chip integrated temperature diode, the actual inside pressure of the module can be checked. This feature is unique for PNDetector’s SDD modules.

The getter can be reactivated by heating with an electrical current of about 5 A in a defined procedure. In the event that the getter reaches its capacity limit, the pressure increases faster. When the inner module pressure is in the range between 0.02 mbar to 0.1 mbar, PNDetector recommends reactivation of the getter for maintaining the advantages of the vacuum housing. In this range, the first decrease of the Peltier cooling efficiency can be observed (see fig. 3).
Benefits of real vacuum housing

Long-term detector stability is ensured by high efficiency vacuum bake-out, optimized module materials and integrated modern non-evaporable getter materials. Minimized humidity prevents condensation and corrosion risk inside the module.

Reduction of the Peltier cooling power by about 50% compared to a standard module with 25 mbar N\textsubscript{2} filling. An operation temperature of -30°C is reached by significantly less than 1 W power consumption (see fig. 4).

Improvement of spectroscopic performance achieved by vacuum conditions inside the module is due to a reduced contribution of the chip surface to the overall signal capacitance. Improved spectroscopic resolution values have been measured on SDD-30-BeP Complete Modules in comparison to standard SDD modules (see fig. 5). All other qualities of the SDD module are kept unchanged.

The Complete – modules ready for test and delivery

<table>
<thead>
<tr>
<th>Module</th>
<th>FWHM*</th>
<th>Peak-to-Background*</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDD-30-130pnW BeP Complete</td>
<td>129 eV</td>
<td>10,000</td>
</tr>
<tr>
<td>SDD\textsuperscript{plus}-30-128pnW BeP Complete</td>
<td>127 eV</td>
<td>10,000</td>
</tr>
<tr>
<td>SDD-10-130 BeP Complete</td>
<td>129 eV</td>
<td>4,500</td>
</tr>
</tbody>
</table>

*) typ. values @ Mn-K\textalpha, -30 °C, input count rates 2-20 kcps, shaping time 1-2 µs
Module dimensions
SDD-30-130pnW BeP Complete
SDD\textsuperscript{plus}-30-128pnW BeP Complete

Pin layout
SDD-30-130pnW BeP Complete
SDD\textsuperscript{plus}-30-128pnW BeP Complete

Specifications
SDD-30-130pnW BeP Complete
SDD\textsuperscript{plus}-30-128pnW BeP Complete

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SDD-30-130pnW BeP Complete</th>
<th>SDD\textsuperscript{plus}-30-128pnW BeP Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active area:</td>
<td>30 mm\textsuperscript{2}</td>
<td></td>
</tr>
<tr>
<td>Collimated area:</td>
<td>26.4 mm\textsuperscript{2}</td>
<td></td>
</tr>
<tr>
<td>Internal collimator:</td>
<td>Zirconium D=5.8 mm</td>
<td></td>
</tr>
<tr>
<td>Module entrance window:</td>
<td>8 µm BePlus</td>
<td></td>
</tr>
<tr>
<td>Radiation hardness:</td>
<td>(&gt; 10^{12}) photons</td>
<td></td>
</tr>
<tr>
<td>Temperature diode sensitivity:</td>
<td>-2.78 mV/K @ I=2.7µA</td>
<td></td>
</tr>
<tr>
<td>Pressure sensor range:</td>
<td>0.001 ... 0.1 mbar</td>
<td></td>
</tr>
<tr>
<td>Cooling power consumption</td>
<td>\leq 1 W (I_{\text{FET}}\text{typ}. 0.6A)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

February 2017
The Complete - XRF Preamplifier Module

Compact XRF Detector Systems in Customer Specific Housing

The Complete SDD Modules combine best SDD chip performance with real vacuum housing. The excellent energy resolution at moderate temperatures and short shaping times is accomplished in a vacuum housing with reactivatable getter and sensors for monitoring the vacuum over detector lifetime.

The XRF Preamplifier Module XRP

is the compact version of the XRF detector system based on the Complete SDD Modules. It provides the X-ray signal of the sample with high speed and high resolution as an analogue output. Bias voltages for the SDD module as well as the reset pulse are generated internally. The system allows monitoring the vacuum conditions inside the SDD modules and supports the reactivation of the getter, maintaining the module vacuum. This guarantees a long lifetime with undisturbed performance.

The compact housing is designed for easy integration into customer systems as a single detector or in a line or matrix configuration with a pitch down to 20 mm. Further specific housings or direct integration in customer systems are possible.

Key Benefits

- Compact XRF detector system for easy integration into customer equipment
- For use with digital pulse processor (DPP)
- Operation at moderate chip cooling
- Allows monitoring of the SDD module pressure and temperature
- Supports getter reactivation inside the module
- Optional customer specific housing
**Functionality**

The XRF Preamplifier Module consists of a SDD module and a detector housing including preamplifier electronics and cooling interface (Fig. 1). The SDD chip is mounted in a vacuum module with reactivatable getter and pressure sensor for monitoring the vacuum. The SDD chip is cooled by a small thermoelectric cooler (Peltier 1). The heat dissipation to the external heatsink where the detector has to be mounted is realized by the compact aluminum housing. The temperature of the SDD chip is measured by means of a small temperature diode on chip level.

The SDD is operated in a charge sensitive amplifier configuration with pulsed reset mode. PNDetector’s SDDs are characterized by the chip-integrated Junction Field Effect Transistor (JFET). This unique feature reduces the parasitic capacitances to a minimum and enables optimum performance at short processing times. The signal charge collected at the SDD anode is reset by the reset diode (Fig. 3). The XRF-detector works in comparator mode, i.e. the reset pulse sets in as soon as the voltage of the output signal reaches a certain threshold (“reset on demand”).

**XRF Detector System Output Signals:**

<table>
<thead>
<tr>
<th>Signal parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal polarization</td>
<td>positive</td>
</tr>
<tr>
<td>Ramp voltage range</td>
<td>±0.5V ... ±1.0V</td>
</tr>
<tr>
<td>Gain</td>
<td>5 ... 10mV/keV</td>
</tr>
<tr>
<td>Reset frequency</td>
<td>reset on demand</td>
</tr>
<tr>
<td>Chip temperature signal</td>
<td>-2.78mV/K</td>
</tr>
<tr>
<td>Module pressure signal</td>
<td>calibrated</td>
</tr>
</tbody>
</table>

*depending on module type
The Complete - XRF Preamplifier Module

Characteristics

**Best Energy Resolution**

@ moderate chip cooling

![Graph showing FWHM vs. Peaking Time for different temperatures (T= +10°C, 0°C, -10°C, -20°C, -30°C). The graph indicates the performance of XRP-30-128-100-BeP Complete measured with DPP @ ICR=20kcps.]

**Detector Quantum Efficiency**

![Graph showing Quantum Efficiency vs. Energy for different configurations. The graph illustrates the efficiency of SDD-Chip and SDD + 8um Be Window.]

**High Throughput**

![Graph showing QCR vs. ICR for different peaking times (0.1, 0.2, 0.3, 0.6, 1.2, 2.4, 4.8). The graph presents the performance of XRP-30-128-100-BeP Complete measured with DPP @ ICR=20kcps.]

**Superior Radiation Hardness**

![Graph showing FWHM vs. Radiation Dose (photons/10mm² active SDD-Area) for the XRP-30-128-100-BeP Complete.]

The Complete - XRF Preamplifier Modules XRP

<table>
<thead>
<tr>
<th>Preamplifier Module</th>
<th>Active SDD chip area</th>
<th>FWHM*</th>
<th>Peak-to-Background</th>
<th>XRF Window</th>
<th>Collimator</th>
</tr>
</thead>
<tbody>
<tr>
<td>XRP-10-130-xxx-BeP Complete</td>
<td>10 mm²</td>
<td>129 eV</td>
<td>4.500</td>
<td>Beryllium</td>
<td>Zr Ø 3,2 mm</td>
</tr>
<tr>
<td>XRP-30-128-xxx-BeP Complete</td>
<td>30 mm²</td>
<td>127 eV</td>
<td>10.000</td>
<td>Beryllium</td>
<td>Zr Ø 5,8 mm</td>
</tr>
</tbody>
</table>

*Typ. values @ Mn-Kα, -30 °C, input count rates 20 kcps, peaking time 4.8 µs, measured with DPP

Housing Version

Fig. 4  Fig. 5  Fig. 6  Fig. 7
The Complete - XRF Preamplifier Module

Connectors

Connectors for Getter Reactivation
Output Signal Connector
Passive Cooling Connection
Supply Voltage Connector

Power Supply

<table>
<thead>
<tr>
<th></th>
<th>Typ.</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low voltage</td>
<td>+12 V</td>
<td>11.9V ... 12.1V (30mV&lt;sub&gt;pp&lt;/sub&gt; ripple)</td>
</tr>
<tr>
<td>Low voltage</td>
<td>-20 V</td>
<td>-19.9V ... -20.1V (30mV&lt;sub&gt;pp&lt;/sub&gt; ripple)</td>
</tr>
<tr>
<td>High voltage</td>
<td>-180V</td>
<td>-179V ... -181V (30mV&lt;sub&gt;pp&lt;/sub&gt; ripple)</td>
</tr>
<tr>
<td>Peltier current</td>
<td>0.6 A</td>
<td>0 ... 1.5 A</td>
</tr>
</tbody>
</table>

PND Supply Unit XRU may be used for power supply, temperature control and pressure monitoring inside the module.

Housing Versions & Dimensions

XRP-__-___-00 BeP Complete
XRP-__-___-01-BeP Complete
XRP-__-___-02-BeP Complete

Further housings on request

Contact PNDetector:
PNDetector GmbH
Otto-Hahn-Ring 6
81739 München
Germany

Phone: +49 (0)89 – 309087-100
Fax: +49 (0)89 – 309087-110
Email: sales@pndetector.de
www.pndetector.de

June 2018
The Complete XRF Detector System

High Resolution XRF Spectroscopy Combined with High Reliability

The Complete SDD Modules combine best SDD chip performance with real vacuum housing. The excellent energy resolution at moderate temperatures and short shaping times is accomplished in a vacuum housing with reactivatable getter and sensors for monitoring the vacuum over detector lifetime.

The Complete XRF Detector System

is the operation platform for Silicon Drift Detector (SDD) modules in the Complete Series. It provides the X-ray signal of the sample with high speed and high resolution as analogue output. The system allows monitoring of the vacuum conditions inside the SDD modules and supports the reactivation of the getter, holding the module vacuum down, which guarantees a long lifetime with undisturbed performance.

The High Resolution Detector System

works with external analogue shapers, ADC and multichannel analyzer (MCA) as well as with digital pulse processor (DPP). It provides the analogue output signal and a gate signal synchronized with the reset pulse. The SDD voltages as well as the reset pulse are generated internally.

Application in Microanalysis and Industry

Individually pre-adjusted system parameters and the right selection of the SDD types and the module windows lead to optimum performance and reliability for your specific application.

XRF Windows

Planar Thin Windows (Si₃N₄) allow detection of low energy photons starting from C-Kα. For all other XRF applications, where light element analysis is not needed, Beryllium windows are the standard.

A Second Peltier Cooler Option

helps to dissipate the heat from the module. This allows to operate the XRF detection system in warm environments.
Functionality

The XRF Detector System consists of a Silicon Drift Detector module and a detector housing including preamplifier electronics and cooling interface (Fig. 1). The SDD chip is mounted in a vacuum module with reactivatable getter and pressure sensor for monitoring the vacuum. The SDD chip is cooled by a small thermoelectric cooler (Peltier 1). Optionally, a second peltier element (Peltier 2) is integrated in the detector system housing to support the heat dissipation to the external heatsink where the detector has to be mounted. The temperature of the SDD chip is measured by means of a small temperature diode on chip level. Furthermore, a PT-1000 sensor is installed at the end of the cooling rod and can be used for controlling the bias current for Peltier 2.

The SDD is operated in a charge sensitive amplifier configuration with pulsed reset mode. PNDetector’s SDD’s are characterized by the chip-integrated Junction Field Effect Transistor (JFET). This unique feature reduces the parasitic capacitances to a minimum and enables optimum performance at short processing times. The signal charge collected at the SDD anode is reset by the reset diode (Fig. 3). The XRF-detector works in comparator mode, i.e. the reset pulse sets in as soon as the voltage of the output signal reaches a certain threshold (“reset on demand”). Together with the reset pulse, a gate signal is created for the data processing with analogue shaper, ADC and MCA (Fig. 3).

XRF Detector System output signals:
- Signal polarization: positive
- Ramp voltage range*: symmetric ±0.2V ... ±2.0V
- Gain*: 5 ... 15mV/keV
- Reset frequency: reset on demand 200Hz ... 20kHz
- Gate signal, length*: TTL, 5 ... 50µs
- Chip temperature signal: -2.78mV/K
- Module pressure signal: calibrated

* preadjusted according to the application
The Complete - XRF Detector System

Characteristics

Energy Resolution

@ moderate chip cooling

![Energy Resolution Graph]

Light Element Performance

![Light Element Performance Graph]

Throughput

![Throughput Graph]

XRF Window Options

![XRF Window Options Graph]

The Complete - XRF Detector Systems XRS

<table>
<thead>
<tr>
<th>System</th>
<th>Active SDD chip area</th>
<th>FWHM*</th>
<th>Peak-to-Background</th>
<th>XRF Window</th>
<th>Collimator</th>
</tr>
</thead>
<tbody>
<tr>
<td>XRS-10-130-xxx-BeP Complete</td>
<td>10 mm²</td>
<td>129 eV</td>
<td>4,500</td>
<td>Beryllium</td>
<td>Zr Ø 3.2 mm</td>
</tr>
<tr>
<td>XRS-30-128-xxx-BeP Complete</td>
<td>30 mm²</td>
<td>127 eV</td>
<td>10,000</td>
<td>Beryllium</td>
<td>Zr Ø 5.8 mm</td>
</tr>
<tr>
<td>XRS-10-125-xxx-BeP Complete</td>
<td>10 mm²</td>
<td>125 eV</td>
<td>15,000</td>
<td>Beryllium</td>
<td>Zr Ø 3.1 mm</td>
</tr>
<tr>
<td>XRS-10-125-xxx-PTW Complete</td>
<td>10 mm²</td>
<td>125 eV</td>
<td>15,000</td>
<td>PTW</td>
<td>Zr Ø 3.1 mm</td>
</tr>
</tbody>
</table>

Other versions available on customer request.

*) typ. values @ Mn-Kα, -30 °C, input count rates 2-20 kcps, shaping time 1-2 µs, respectively peaking time 4.8 µs, when measured with DPP
Dimensions

Option:
Tube length can be modified according to customer requirements.

Power Supply

<table>
<thead>
<tr>
<th>XRF Detector system power supply</th>
<th>Typ.</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low voltage</td>
<td>+12 V</td>
<td>11.9V ... 12.1V (30mV̵₂ ripple)</td>
</tr>
<tr>
<td>Low voltage</td>
<td>-20 V</td>
<td>-19.9V ... -20.1V (30mV̵₂ ripple)</td>
</tr>
<tr>
<td>High voltage</td>
<td>-180V</td>
<td>-179V ... -181V (30mV̵₂ ripple)</td>
</tr>
<tr>
<td>1st Peltier current</td>
<td>0.6 A</td>
<td>0 ... 1.5 A</td>
</tr>
<tr>
<td>2nd Peltier current (optional)</td>
<td>0.6 A</td>
<td>0 ... 2.5 A</td>
</tr>
</tbody>
</table>

Connectors

Supply Voltage Connector
Gate Connector
Output Signal Connector
Passive Cooling mechanical Connection
2nd Peltier Connector (Option)