We present the design and characterization of a high performance resistance measurement circuit fabricated in a standard 0.35μm CMOS process. The circuit implements two exposed metal electrodes in the topmost metal layer which can be deposited the sensitive thin-film. Test pulse is injected into one electrode, the other electrode is directly fed into a low noise charge sensitive amplifier with selective feedback capacitor. Simulations show that the circuit achieved a 100Ω–10TΩ measuring range and a 10Ω resolution. The first coating film attempt experiment is done, and the following tests are ongoing. These characteristics enable its use as the accurate resistance monitoring sensor device in future thin-film sensitive gas detection applications.

**Introduction**

The Topmetal series sensors are designed by the PLAC’s IC team, fabricated in a standard 0.35μm CMOS process, main features:

- Direct charge collection by the ‘Topmetal’ that is implemented with a topmost and exposed metal patch/electrode;
- Novel ‘Guardring’ structure is established for enhancing the charge collection efficiency and realizing tests by the pulse injection;
- Low Equivalent Noise Charge (ENC): 13.9e- (Topmetal-II-) and 12.4e- (Topmetal-IIa);
- Aiming at the direct charge collecting and measuring in the low background and low noise experiments.

**Topmetal Series Sensor**

**Thin-Film on Topmetal**

Based on the prototype of a series Topmetal pixel sensor with directly charge collection and excellent low noise performance, the front-end of this resistance measurement circuit implements two exposed metal electrodes (Both ‘Topmetal’ and ‘Guardring’) which can be deposited the sensitive thin-film on the surface.

**Table 1: TOPMETAL Sensor Chip Family**

<table>
<thead>
<tr>
<th>Tape-out Date</th>
<th>Chip’s Name</th>
<th>Size [μm²]</th>
<th>ENC [e⁻]</th>
<th>Application background</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012.9</td>
<td>Topmetal-I</td>
<td>6 × 7.3</td>
<td>200</td>
<td>Low background, low noise High</td>
</tr>
<tr>
<td>2014.7</td>
<td>Topmetal-II</td>
<td>8 × 9</td>
<td>13.9</td>
<td>Energy Physics Experiments</td>
</tr>
<tr>
<td>2016.5</td>
<td>Topmetal-IIa</td>
<td>4 × 9</td>
<td>12.4</td>
<td>Neutrinoless Double Beta</td>
</tr>
<tr>
<td>2016.5</td>
<td>Topmetal-S</td>
<td>3 × 2</td>
<td>28.7</td>
<td>Decay (0.9β)</td>
</tr>
<tr>
<td>TBD</td>
<td>Topmetal-S</td>
<td>TBD</td>
<td>&lt;10</td>
<td>TBD</td>
</tr>
<tr>
<td>TBD</td>
<td>Topmetal-S</td>
<td>TBD</td>
<td>&lt;15</td>
<td>Neutrinoless Double Beta Decay (0.9β)</td>
</tr>
</tbody>
</table>

**Preliminary research and Film Coating experiment**

As shown in Fig 5, an independently simplified test module including the two exposed electrodes and the analog front-end is designed in the Topmetal-IIa chip for the preliminary research. The first attempt experiment of coating the thin-film is shown in Fig 6. The coating process is executed on a Magnetic Sputtering Platform and using the Zinc Oxide (ZnO) material.

**Summary and Outlook**

Based on the prototype of a series Topmetal pixel sensor, we propose a high performance resistance measurement circuit fabricated in a standard 0.35μm CMOS process. Simulations show that the circuit achieved a 100Ω–10TΩ measuring range and a 10Ω resolution. These characteristics enable its use as the accurate resistance monitoring sensor device in future thin-film sensitive gas detection applications.

An independently simplified test module is designed in the Topmetal-IIa chip for the preliminary research. The first coating film attempt experiment is done by a Magnetic Sputtering Platform and using the Zinc Oxide (ZnO) material. Further more investigations, tests and design works are ongoing.

**Acknowledgments and References**

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**References:**