N-Type Diffusion Source Wafers for the Semiconductor Industry

PDS® Products phosphorus source wafers offer low cost, in-situ, N-type planar sources for silicon diffusions. In-situ PDS Products eliminate the trade-off between throughput and uniformity for larger diameter wafers.

All grades of N-type PDS Products are available in diameters up to 200 mm. Use of PDS Products enables the user to change source wafer diameter with little or no change in the diffusion process.

AVAILABLE GRADES AND TYPICAL PROPERTIES

N-type PDS Products are mechanically stable, solid diffusion source wafers that combine phosphorus and an inert silicon carbide substrate.

All N-type PDS Products consist of an active component Cerium Pentaphosphate (CeP5O14) or Silicon Pyrophosphate (SiP2O7) carried on an inert porous Silicon Carbide (SiC) substrate. At diffusion temperature, the active component decomposes to form P2O5 vapor, which evolves from the source by direct volatilization. The by-product of the decomposition (CeP3O9 or SiO2) remains on the source wafer.

Features/Benefits

- Extreme flexibility that allows application to many device structures, thereby eliminating capital expense in device conversion.
- Improved yields by gettering oxidation induced stacking faults and improved uniformity across the wafer, across a run and from run-to-run.
- Precision chemical principles make for predictability and repeatability through the controlled introduction of moisture in the diffusion tube, even at temperatures as low as 825°C.
- Moisture modulation of the vapor pressure of the B2O3 - HBO2 system causes a rapid flux of gas, creating excellent uniformity and allowing a damage control mechanism to be established simultaneous to the deposition process.
- A trained staff is maintained to assist in all technical needs and support.

Key Applications

- Emitter
- Collector
- Backside gettering
- Source/drain
- Sinker
- Polysilicon doping
- Solar cell

Target Markets

- Semiconductor manufacturing
- Microelectro-mechanical systems (MEMS)

STACKING ARRANGEMENT

PDS Products sources and silicon wafers are edge-stacked perpendicular to the tube axis in cross-slotted furnace carriers.

<table>
<thead>
<tr>
<th>Grade</th>
<th>PH-900</th>
<th>PH-950</th>
<th>PH-1000N</th>
<th>PH-1025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composition</td>
<td>100% CeP5O14</td>
<td>100% SiP2O7</td>
<td>100% SiP2O7</td>
<td>60% ZrP2O7 30% SiP2O7 10% SiO2</td>
</tr>
<tr>
<td>Temp °C</td>
<td>825-900</td>
<td>875-950</td>
<td>925-1000</td>
<td>975-1025</td>
</tr>
<tr>
<td>Sheet Resistance (Ohm/Sq)</td>
<td>150-15</td>
<td>60-5</td>
<td>25-3</td>
<td>25-3</td>
</tr>
<tr>
<td>Phosphorus Glass Thickness Å</td>
<td>100-650</td>
<td>125-1200</td>
<td>175-1200</td>
<td>100-1250</td>
</tr>
<tr>
<td>Dose atoms / cm²</td>
<td>1.4 x 10¹⁴ to 3.9 x 10¹⁵</td>
<td>3.2 x 10¹⁴ to 2.4 x 10¹⁵</td>
<td>8.4 x 10¹⁴ to 1.1 x 10¹⁶</td>
<td>5.3 x 10¹⁵ to 1.4 x 10¹⁶</td>
</tr>
</tbody>
</table>
GASES AND FLOW RATES
During the evaluation phase of PDS Products, a full boatload of dummy silicon wafers is needed to create the boundary layer condition and achieve meaningful results. Typical total gas flow rates are 6 – 10 slpm, depending on the combination of source wafer and process tube diameters used. Optimization of across the wafer and across the boat diffusion parameter uniformity may require that these flow rates be modified.

SOURCE PREPARATION
Wet chemical cleaning is unnecessary since the sources are manufactured under the most exacting quality standards using raw materials of the highest purity, and are protected from exposure to contaminants both during and after manufacture. Furthermore, due to the porosity of the composition, cleaning agents are difficult to remove completely.

It is recommended that prior to actual product silicon diffusion, new phosphorus source wafers be annealed at the following temperatures in an ambient of 100% N₂:

<table>
<thead>
<tr>
<th>Source</th>
<th>Temperature</th>
<th>Time</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH-900</td>
<td>925°C</td>
<td>For 16 Hrs</td>
<td></td>
</tr>
<tr>
<td>PH-950</td>
<td>900°-950°C</td>
<td>For 8 Hrs</td>
<td></td>
</tr>
<tr>
<td>PH-1000N</td>
<td>950°-1000°C</td>
<td>For 8 Hrs</td>
<td></td>
</tr>
<tr>
<td>PH-1025</td>
<td>1000°-1025°C</td>
<td>For 4 Hrs</td>
<td></td>
</tr>
</tbody>
</table>

1. **Push in and Recovery**: During the recovery step, source boats stacked with Phosphorus and silicon wafers are pushed into a diffusion tube. The tube is then allowed to establish ambient equilibrium. This step is performed in an ambient of 100% N₂ at 750°C-850°C. Typical total gas flow rates are 6-10 slpm, depending on the combination of source wafer and process tube diameters used.

2. **Soak**: During the soak step, the dopant, glass which is uniformly coating the silicon wafers undergoes a reduction reaction in the ambient which results in the formation SiO₂ and phosphorus.

3. **Deglaze**: After the Si wafers are unloaded from the furnace, the excess un-reacted dopant glass is removed by 10 parts DiH₂O to 1 Part HF for 2 minutes at room temperature.

STORAGE
Optimum source wafer storage between uses is in dry N₂ at 400°C. Storage in the mouth of the diffusion tube is not recommended.

FURNACE LOADING AND UNLOADING CYCLES
A slow push during furnace loading (typically 5.0”/ min.) at 700°-800°C is advised. The boats should be allowed to equilibrate for 5-10 min. under N₂ before ramping to use temperature. A subsequent ramp down to 700°-800°C before unloading is also recommended.
PERFORMANCE DATA: PDS PRODUCTS N-TYPE GRADE PH-900

Junction Depth vs. Deposition Time

Sheet Resistance vs. Deposition Time

\( P_2O_5 \) Glass Thickness vs. Deposition Time

PERFORMANCE DATA: PDS PRODUCTS N-TYPE GRADE PH-950

Sheet Resistance vs. Deposition Time

\( P_2O_5 \) Glass Thickness vs. Deposition Time

Junction Depth vs. Deposition Time

PERFORMANCE DATA PDS PRODUCTS N-TYPE GRADE PH-1000N

Sheet Resistance vs. Deposition Time

\( P_2O_5 \) Glass Thickness vs. Deposition Time

Junction Depth vs. Deposition Time