PDS® Products Boron Nitride P-Type Source Wafers

PDS® Products Technical Data

Overview

PDS Products boron nitride wafers offer low cost, in-situ, p-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 P-type PDS Products are manufactured in diameters up to 200 mm.

Grade and Performance

Grade	Temperature Range	Sheet Resistance Range
BN-975	800 – 975 °C	500-20 Ω/□
BN-1100	1000-1100 °C	40-5 Ω/□
BN-1250	1000-1250 °C	40-1.5 Ω/□
BN-HT	1000-1200 °C	20-1 Ω/□

Use of PDS Products enables the user to change source wafer diameter with little or no change in the diffusion process.

Typical Applications include:

- Emitter
- Base
- Collector
- Channel stop
- Isolation
- Guard rings
- Resistor
- Capacitor
- Solar cells
- Source/drain
- Trench structures

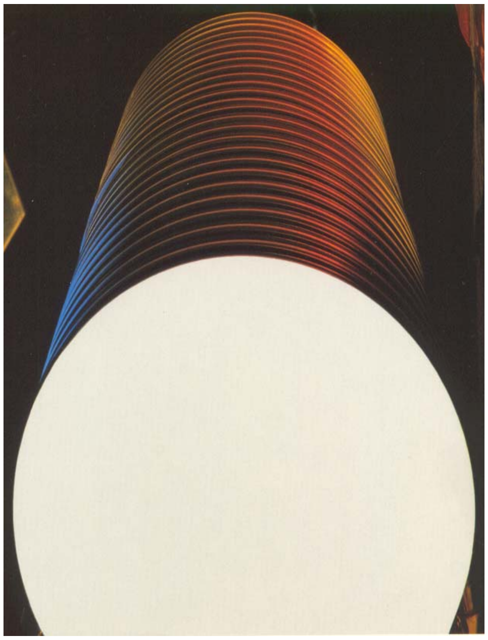
For all applications, Saint-Gobain Advanced Ceramics Boron Nitride offers unparalleled technical guidance based on over 30 years of experience in diffusion technology.

Source Composition

Grade BN-975 is composed of boron nitride and, boric oxide.

Grade BN-1100 & BN-1250 are composed of 60% BN and 40% SiO_2 and 40% BN and 60% SiO_2 respectively.

Grade BN-HT is boron nitride fired at high temperatures to remove all the B_2O_3 and grow diffusion bonds. When activated, B_2O_3 glass forms on the outside of the BN-HT source wafer. This boron glass is controllably transferred to the silicon wafer to produce uniform boron doping results while minimizing silicon surface defects.



Advantages of the PDS Products

- 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 750°C.
- Moisture modulation of the vapor pressure of the B_2O_3- HBO_2 system causes a rapid flux of gas, creating excellent uniformity and allowing a damage control mechanism to be established simultaneous to the deposition process.
- Successful application of the PDS® hydrogen injection process throughout the semiconductor industry.

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Source Use

Stacking Arrangement*

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

Gases and Flow Rates*

When evaluating PDS Products, a full boatload of test and dummy silicon wafers is needed to create the boundary layer condition and achieve meaningful results. Typical total 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

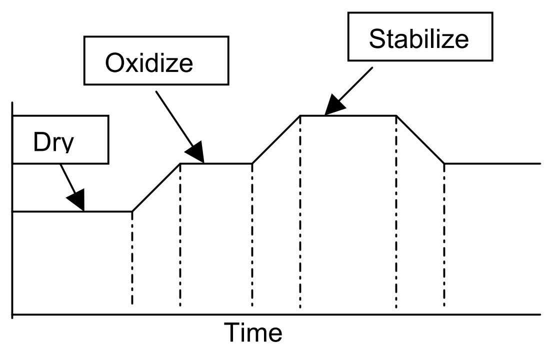
It is necessary that prior to silicon deposition, new wafers have the recommended wafer preparation as shown in Table 1. Wet cleaning of BN-975 and BN-HT is to be avoided.

Since BN-1100 and BN-1250 are BN / SiO_2 compositions, it is necessary to remove some of the SiO_2 with an HF dip followed by a DI-H_2O rinse. This etches some of the SiO_2 away to expose the boron nitride for oxidation. After the surface etch step, a water rinse is to be done to remove any residual HF. Routine re-oxidation may be necessary as the exposed BN is consumed
For all sources, the function of the drying step is to remove entrapped moisture.
The purpose of the initial oxidation process is to grow a thin layer of B_2O_3 glass on the surface of the boron nitride wafer. This will act as the dopant source during subsequent deposition (predisposition) processes.

Table 1 Source Wafer Preparation

	BN-975	BN-1100 & BN-1250	BN-HT
Surface Etch	No	3 Parts Di-H_2O-2 Parts 49% HF @ Room Temp.	No
Rinse	No	Di-H_2O 5 minutes maximum	No
Dry	400°C 100%N_2 1 Hour	400°C 100%N_2 2 Hours	400°C 100%N_2 1 Hour
Oxidize	900- 950°C 100% O_2 30 Minutes	1000°C 100% O_2 30 Minutes	950°C 100% O_2 30 Minutes
Stabilize	At Use Temp 100% N_2 30 Minutes	1100-1250°C 100% N_2 30 Minutes	1100°C 100% N_2 6 Hours

Wafer Preparation Process line Diagram



* See Technical Bulletin "Furnace Carriers for PDS Products in Diffusion Processing"

Process Outline for Single Step Diffusion

Step	Ambient	Time	Function
Push in & Recovery	N_2 (100%)	15 Min.	Thermal Equilibrium Thin Oxide Growth
Soak	N_2 (100%)	Variable	Defect Control Resistivity Target
Deglaze	10:1 HF	2 Min	Remove Unreduced Glass
Low Temperature Oxidation (LTO)	100% O_2	20 Min.	Remove Si-B Layer and defects.

Push in and Recovery

During the recovery step, source boats stacked with BN-975 wafers and silicon wafers are pushed into a diffusion tube. The tube is then allowed to establish ambient equilibrium. This step is generally performed in an ambient of 50% N_2 and 50% O_2 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. The N_2/O_2 ambient during the recovery step grows a thin layer of SiO_2 in the mask window regions. This thin layer of SiO_2 masks B_2O_3 diffusion during the push in cycle, thus minimizing or eliminating the sheet resistivity gradients due to the first wafer in being the last wafer out.

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 of a thin insoluble layer of silicon-boride, Si-B, at the silicon surface. The Si-B layer serves traps crystal damage at the silicon/ SiB interface through a strong gettering action. In essence, the function of the soak step is to control damage while obtaining the targeted sheet resistivity (See Figures 3A, B & C.).

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.

Low Temperature Oxidation (LTO)

The function of the LTO step is to oxidize the Si-B layer and a thin layer of Si below it. Oxidizing this thin Si layer will immobilize most of the crystal defects in the oxide. A steam or O_2 ambient is typically used to cause the rapid oxidation of the Si-B layer and it's silicon interface region before harmful propagation of the defects into the silicon can occur. This allows the subsequent drive cycle to be damage free. (See LTO Technical Bulletin)

Storage

Optimum PDS Products grade Boron Nitride wafer storage between uses is in dry N_2 at 400°C in the center zone of the diffusion furnace.

Storage in the mouth of the diffusion tube is not recommended. If the history of the source boat is unknown, a minimal one hour anneal at anneal temperature is recommended prior to product silicon diffusion.

Furnace Loading and Unloading Cycles

For best results with all wafer types, a slow push (typically 5.0"/ min.) at 700°C-800°C is advised.
Boron Nitride wafer boats should be inserted and allowed to equilibrate for 5-10 min. under an N_2 ambient before ramping to use temperature. During the ramp sequence, only N_2 gas ambient is to be used. For BN-1100 & BN-1250, if the furnace system is tight, a 1-5% O_2 may to be added. The soak and the subsequent ramp down to 700°C-800°C is to be performed in an N_2 only ambient.

Figure 3A. **Sheet Resistance vs. Deposition Time and Temperature (No H_2- Injection) for BN-975**

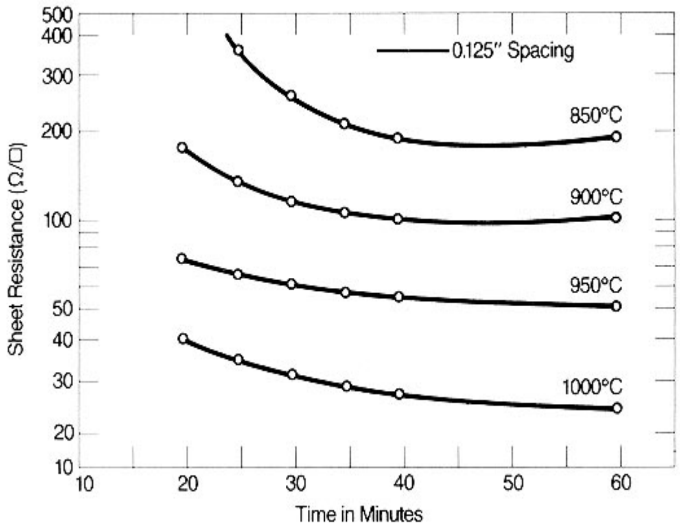


Figure 3B. **Sheet Resistance vs. Deposition Time and Temperature for BN-HT**

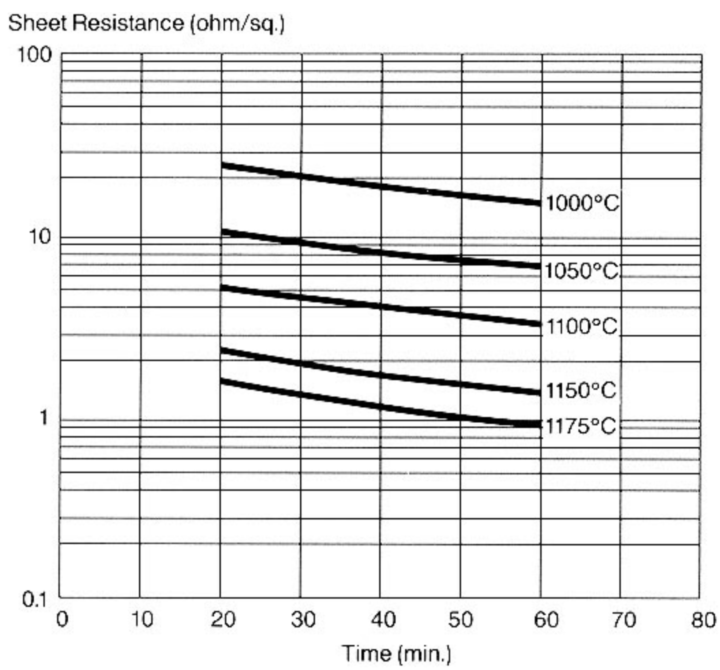
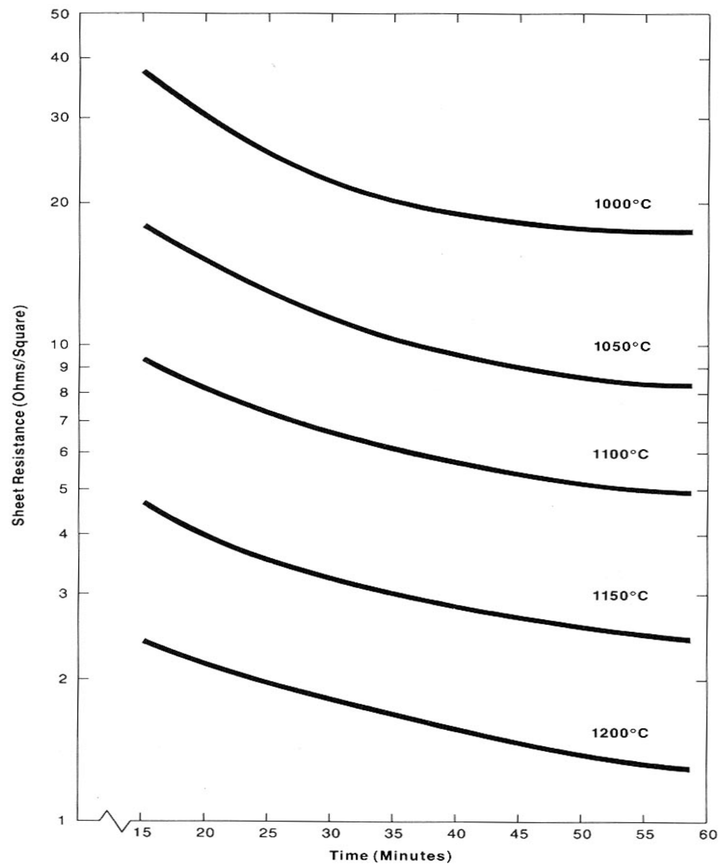


Figure 3C. Sheet Resistance vs. Deposition Time and Temperature for BN-1100 and BN-1250



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