

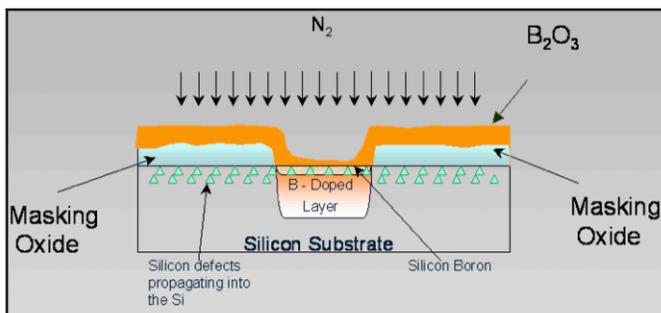
P-Type Planar Diffusion Sources

Low Temperature Oxidation and Silicon-Boron (Si-B) Layer

OVERVIEW

Depositions using PDS® Products P-type boron nitride solid source wafers on silicon substrate develop a silicon-boron phase (boron skin). The phase is a result of excess boron reacting with the silicon surface and is typically 200 Å thick and is not effected by HF. This boron skin is the fundamental reason for the gettering properties of the BN-975.

Figure 1. Silicon Wafer Cross Section After Boron Diffusion



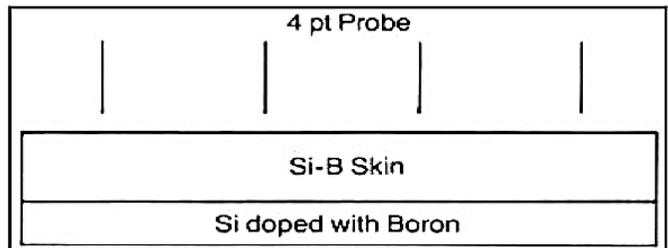
Additional diffusion processing during the IC manufacturing process mandates the removal of the boron skin. If this layer is not removed, any defects “held” within this layer will propagate deeper into the silicon substrate during subsequent thermal processing. In addition to the defect issue, the Si-B layer will act as a source of boron. The significance is higher surface concentration than expected.

After the Si wafers are unloaded from the furnace, the excess un-reacted dopant glass is removed by a boron etch, such as 10:1 HF. Many different boron-glass etches, even hot water, can be used for this purpose. After deglaze, the silicon surface is hydrophilic (i.e. wets) due to the presence of the un-etchable Si-B layer. This layer is typically 200Å thick. At this stage of the process, wetting of the silicon is acceptable, as the next stage of treatment will remove the Si-B and some Si along with the defects.

If a four point probe resistivity check is performed at this time, the sheet resistivity measurements will be lower than after the Si-B phase is removed due to the fact that the probe is measuring the lower resistivity of the Si-B

layer in parallel with the diffused layer beneath it (Figure 2). Measurements at this time are valid process checks. Deglazing and probing following the low temperature oxidation will determine the amount of resistivity shift. Typically, there is a 5% to 10% resistivity shift.

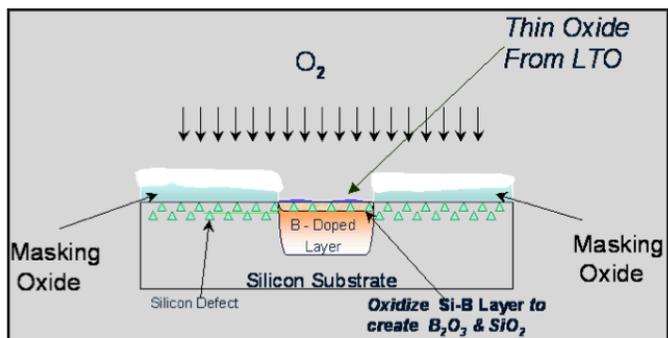
Figure 2. Si-B layer in parallel with the diffused layer



LOW TEMPERATURE OXIDATION (LTO)

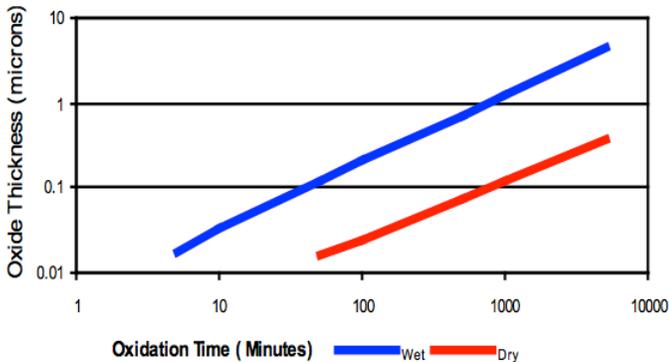
The function of the LTO step is to oxidize the Si-B layer and a thin layer of Si below it (Figure 3). Oxidizing this thin Si layer will immobilize most of the crystal defects in the oxide. A steam or O₂ ambient (Figure 4.) is typically used to cause the rapid oxidation of the Si-B layer and it’s silicon interface region before harmful propagation of the defects into the silicon can occur. This allows the subsequent drive cycle to be damage free.

Figure 3. Oxidation of Si-B and a thin layer of Si



Planar Diffusion Sources

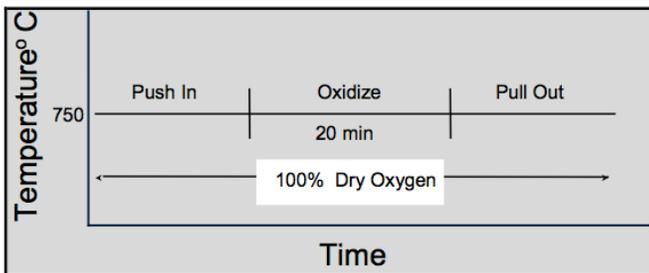
Figure 4. Wet vs. Dry Silicon Oxidation Curves



LOW TEMPERATURE OXIDATION (LTO) PROCEDURE

LTO is a three step process

1. HF etch (Deglaze) after deposition
 - 10:1 DiH₂O to 49% HF - 2 minutes
 - Removes B₂O₃ glass from the exposed silicon surface
 - Also removes some of the doped masking oxide
2. Silicon Oxidation
 - 750°C for 20 minutes in 100% O₂



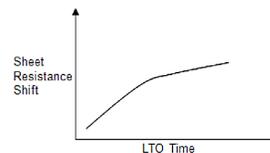
3. Deglaze after LTO:

- 10:1 DiH₂O to HF - 2minutes
- Removes the B₂O₃ / SiO₂ layer created by oxidizing the Silicon Boron (Si-B) layer.
- Removes defects “pinned” in the oxidized Si-Blayer
- Also removes some of the masking oxide

OPTIMIZING THE LTO PROCESS

To determine the optimum LTO cycle, it is necessary to produce a load of wafers through to the first deglaze. The lot is then split and the wafers are put through incremental LTO cycles after which they are checked by one of several methods to determine the required LTO cycle.

A common method to determine the LTO cycle is to measure incremental percent changes in sheet resistance after the deglaze after LTO step. A “knee” in percent change vs. LTO time curve (Figure 5) will correspond to the time required to remove the Si-B phase. It is desirable to oxidize 50-100 angstroms beyond the Si-B phase as this traps the defects in the oxide. Other methods for discerning the LTO cycle, such as deglazing and Sirtl or Wright etching to determine defect density and incremental oxide growth measurements, can be used. This step, kept during production, is used during process characterization and development. If the deglaze step



is omitted from production, the subsequent drive should be run in a pure O₂ environment to prevent the formation of un-etchable silicon compounds.

These recommendations are to be used as a starting point for all Boron Nitride PDS Products. Following these recommendations will:

1. Develop a defect free boron diffused layer
2. Standardize your diffusion process for technical assistance
3. Allow defect free subsequent thermal processing.

Please contact your PDS Products specialist at bnsales@saint-gobain.com for further information.



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