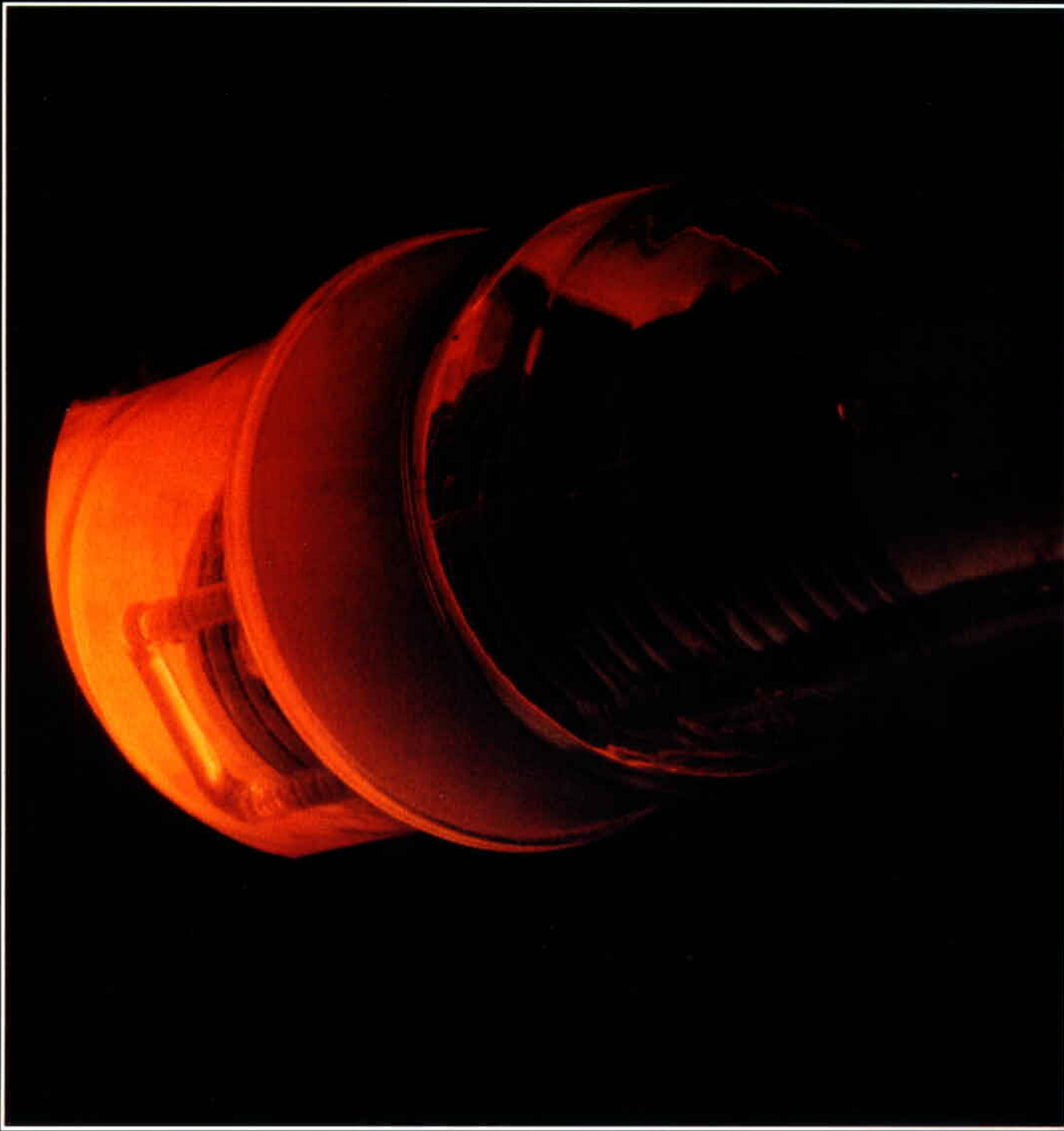
BoronPlus®

High-Purity Planar Dopant Sources



ISO CERTIFIED 9002/14001

TECHNEGLAS

BoronPlus®

Diffusion Sources:

Provide pure boron depositions.

- Impurity analyses of doped silicon wafers show depositions of high purity are achieved.

Produce uniform sheet resistivities.

- Uniformities typical of the planar diffusion technique (2% across the silicon, 3% across the boat, and 4% run-to-run) or better are obtained.

Exhibit long lifetimes.

- Hundreds of use-hours have been reported by various users.

Are safe to use.

- The sources do not require the use of explosive gases and do not generate toxic off-gases.

Feature ambient versatility.

- Depositions can be made in nitrogen, argon, or helium.
- Thicker glassy films can be deposited in nitrogen containing controlled amounts of moisture.
- The sources can be held in oxygen without adversely affecting subsequent runs.

Reduce operator handling.

- Require no complex metering equipment.
- Need no periodic reactivation cycles.
- Exhibit a minimum of water absorption.
- Extend time between tube deglazing operations.
- Can be removed from diffusion boats for periodic boat deglazing.

Minimize silicon damage.

- Many users have obtained less silicon damage on wafers doped with BoronPlus sources than other p-type diffusion techniques.

BoronPlus®拡散ソース

高純度のデポ

- BoronPlusで拡散すれば、シリコンウエーハは高純度のものが得られます。

均一性の高いRs

- 均一性は一般的な固体ソース(Si内2%、ボート内3%, ランツウランで4%)より優れています。

ライフタイムの経済性

- ライフタイムが長く数百時間の使用が可能です。

高い安全性

- 危険性ガスの使用は不要で、毒性オフガスの発生がなく安全です。

各種ガスが使える

- N_2はもとより、ArやHeでも拡散ができます。
- 湿気をコントロール量加えたN_2雰囲気下で厚いガラス層が作れます。
- ソースはO_2中に置いても悪影響は受けません。

簡便なデポ操作

- 複雑なガス流量コントロール装置が要りません。
- 定期的な再活性化処理が不要です。
- 吸湿性が極めて低くなっています。
- チューブを頻繁にクリーニングする必要がありません。
- ボートクリーニングが簡単にできます。

少ないシリコンダメージ

- BoronPlusで拡散すると、シリコンダメージが大変低レベルになります。

佳硼® 掺杂剂源

提供纯硼沉积

- 将由佳硼所掺杂的硅片进行杂质分析结果显示高纯度硼沉积.

制造均匀薄层电阻率

- 能取得比典型的平面扩散技术所得的更佳的均匀性（同硅片内的均匀性为百分之二，同一扩散舟内的不同硅片的均匀度为百分之三，不同批的硅片为百分之四）.

有超常寿命

- 许多用户都有几百小时以上的实际应用经验.

应用上完全安全

- 应用佳硼掺杂剂时不需要用到任何爆炸性气体，也不会在应用过程中发出毒性气体.

适应多样化周围环境

- 沉积过程可用氮，氩气等.
- 加厚的玻璃性薄膜可于加少许水汽的氮气中进行.
- 佳硼掺杂源可置于氧气中而不影响品质.

减少操作人员处理

- 不需要复杂的仪表控制的装置.
- 不需要定期的再激活过程.
- 低吸水性.
- 增长扩散管除玻璃程序之间的时间.
- 于定期扩散管除玻璃程序时可由扩散管中取出.

减低硅片损坏

- 许多用户在利用佳硼掺杂源中取得比其他掺杂剂更佳的效果.

BoronPlus

Diffusion Sources:

deposition을 위한 순수한 boron공급.

■ 도핑된 실리콘 웨이퍼의 불순물 분석에서 나타난 고순도의 deposition을 달성.

균일한 sheet resistivities의 창출.

■ 대표적인 planar diffusion기술의 uniformities.(2% within wafer, 3% wafer to wafer, 4% run to run)또는 그이상을 획득.

긴 수명.

■ 많은 고객에 의해 수백시간 사용을 입증.

사용상 안전.

■ source를 사용하면 폭발성 gas 그리고 독성 gas 사용이 불필요.

다양한 특징.

■ 대포지션을 질소, 알곤 또는 헬륨에서 수행.
■ 습도를 제어한 질소에서 두꺼운 유리막 대포지션 가능.
■ source들은 차후 run에 악영향 없이 산소 분위기에서 특성 유지.

작업자 handling의 감소.

■ 복잡한 계량기기가 불필요.
■ 주기적인 반응 cycles가 불필요.
■ 수분흡수의 최소화
■ Tube의 deglazing작업 간격을 연장.
■ 주기적인 boat의 deglazing을 위해 diffusion boat로부터 source제거 가능.

최소의 silicon damage.

■ 많은 고객들이 다른 p-type diffusion 기술보다 BoronPlus source로 도핑 했을때 wafer에 silicon damage가 훨씬 적다고 입증.

BoronPlus®擴散硼片

高純度的硼沉積

■使用BoronPlus擴散硼片後，在被擴散的矽晶片上的硼沉積經過不純物分析證實純度很高.

均勻的片電阻值

■可得到與一般平面擴散技術相同或更佳的均勻性(在矽晶片內2%，在晶舟間3%，不同製造批量間4%).

使用壽命長

■經多數使用者證實，可使用甚至長達數百小時.

安全性高

■不需用到具爆炸性的氣體，且不產生有毒的氣體.

適用多樣化的週圍環境

■可在N_2, Ar或He中作擴散沉積.
■在氮氣(N_2)中通入微量控制的水氣(moisture)可得到較厚的玻璃層沉積.
■硼片可在氧氣(O_2)中操作不會影響後續批量的均勻性.

操作簡便

■不需複雜的流量控制設備.
■不需定期的再活化處理.
■吸水率最小.
■可延長爐管"去玻璃處理"的清理時間.
■硼片很容易從晶舟上取下，以便晶舟的定期"去玻璃處理".

對矽晶片的損害減至最少

■許多使用者證實，用BoronPlus比用其他p-type的擴散技術對矽晶片的損害明顯地減少.

BoronPlus® Planar Dopant Sources Have Widespread Uses.

BoronPlus planar diffusion sources have found widespread application in many semiconductor processing operations since they were first introduced to the industry in 1975. The increasing popularity of the sources can be attributed in part to the desirable combination of properties they exhibit including the unique diffusion-controlled evolution rate of B_2O_3 during use. The BoronPlus sources require a minimum amount of handling during use and produce a pure deposition on large diameter silicon wafers with excellent uniformity. In general, the BoronPlus sources exhibit a minimum of the undesirable characteristics of various other gas, liquid, and solid boron sources while retaining many of their desirable features.

Five Sources Meet Varying Needs.

Five BoronPlus sources have been developed to meet the variety of needs in silicon processing. The useful operating temperatures for each source is given below. The overlapping temperature ranges provide the diffusion engineer flexibility in selecting diffusion sources for various applications.

Source Type	Recommended Temperature Range, °C	Approximate Sheet Resistivity, Ω/□
GS-126	Below 1000	Above 15
GS-139	975-1075	35-5
GS-183	1000-1100	20-5
GS-245	1050-1125	10-3
GS-278	1100-1175	5-1

Each source is produced from a glass containing B_2O_3 and the extremely stable oxides of BaO, MgO, Al_2O_3 and SiO_2. The glass composition is held within tight limits to assure melt-to-melt uniformity. The raw materials are melted and cast into billets utilizing a unique glass manufacturing process that ensures a homogeneous distribution of boron oxide throughout the bulk of the material. Each glass billet is subsequently nucleated and crystallized in a uniform way to provide the necessary high temperature rigidity to the sources. The billets are then turned to the desired diameter and sliced into wafers using a conventional ID saw.

BoronPlus Sources Have High Purity.

All five BoronPlus diffusion sources are produced from high-purity raw materials. A typical impurity analysis of a melt, when measured on a spark source mass spectrograph, is given in Table I.

Figures 1 and 2 show relative amounts of sodium and iron found on the surfaces of silicon wafers doped with a BoronPlus source, a BN source, and a typical spin-on solution of B_2O_3 detected with a secondary ion mass spectrometer (SIMS). Although absolute amounts of impurities were not determined by this technique, the relative concentrations of impurities can be estimated by comparing the areas under the curves. These data indicate that most of the impurities are strongly tied up in the glassy matrix of the BoronPlus sources and do not evolve at a high rate during use. The result is a relatively pure glassy film of B_2O_3 being deposited on the silicon wafer surface.

Table I

TYPICAL IMPURITY ANALYSIS OF BoronPlus SOURCE

Metal	PPM	Metal	PPM
Na	2	Pt	< 5
K	< 1	Rh	< 1
Li	< 1	As	< 0.5
Fe	2	P	< 5
Pb	1	Sb	< 0.5
Cr	2	Bi	< 0.5
Cu	0.5	V	< 1
Sn	< 0.5	Co	< 2
Zn	< 2	Mo	1
Ti	2	Ca	20
Ni	2	Sr	20
Ag	< 0.5	Mn	< 1
Au	< 0.5		

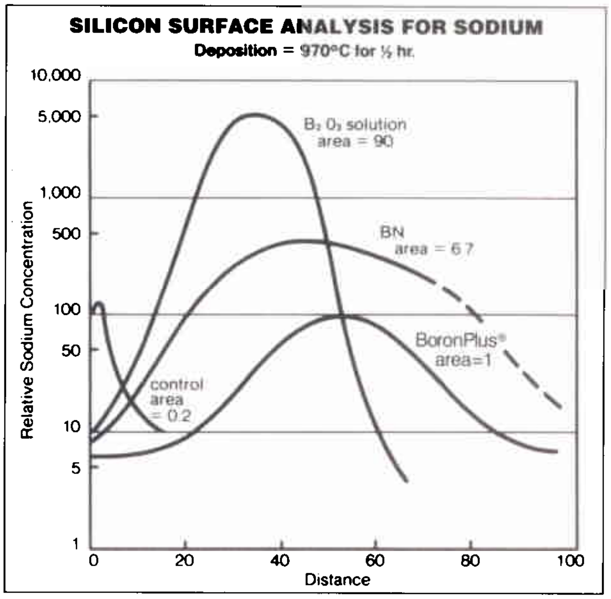


Figure 1

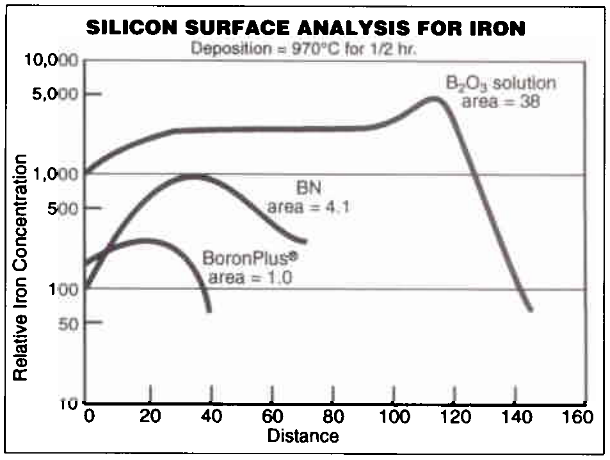


Figure 2

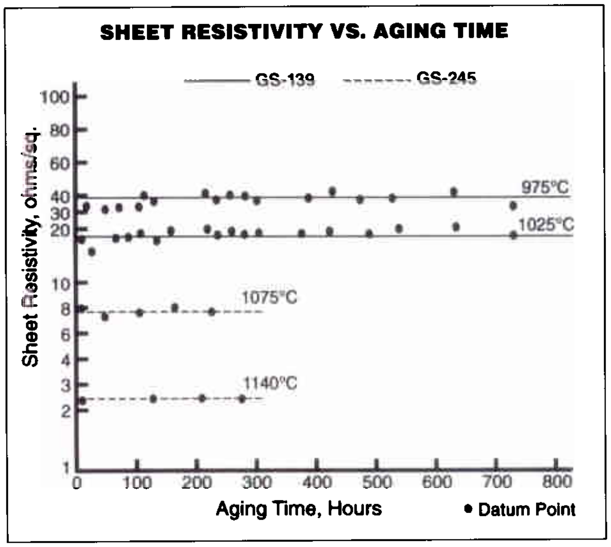


Figure 3

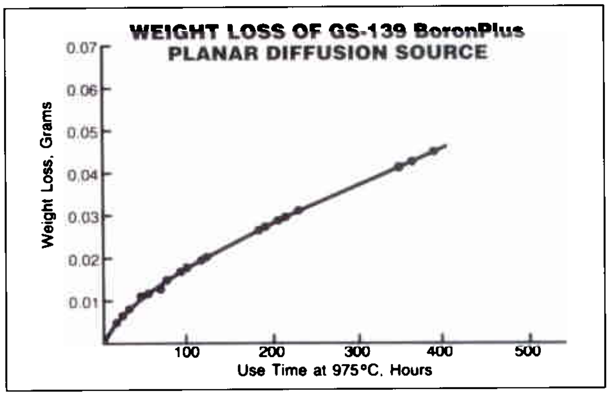


Figure 4

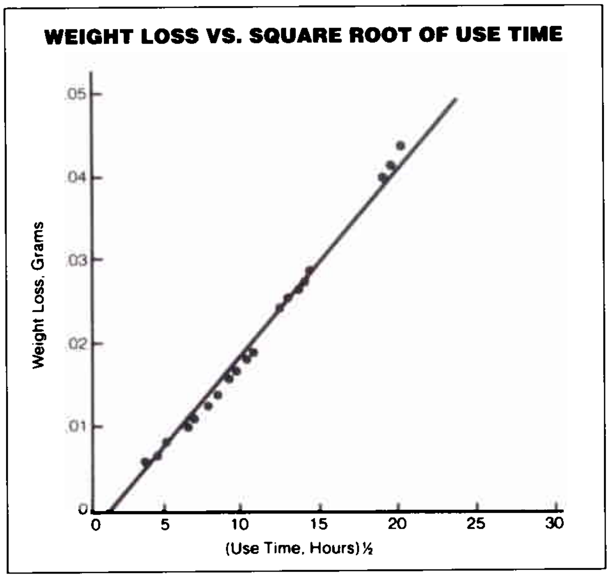


Figure 5

■ BoronPlus Sources Show Long Lifetimes.

Several techniques exist for estimating the potential lifetime of a planar diffusion source. One method is to periodically dope a silicon wafer with a source held in a diffusion furnace and observe how the resulting sheet resistivity varies with time. Figure 3 shows the sheet resistivity obtained on silicon wafers doped for 30 minutes with GS-139 BoronPlus sources that were held at 975˚C and 1025˚C. Little change is observed during the 700-800 hours of test time. Similar data are shown for GS-245 sources.

A second method of estimating the source's lifetime is to measure the amount of weight loss at a use temperature as the B_2O_3 evolves. When the source no longer loses weight, the evolution of B_2O_3 has ended. A weight loss curve plotted in Figure 4 for the GS-139 BoronPlus source also indicates that hundreds of hours of use are available at 975˚C.

The typical weight loss curve in Figure 4 shows that the B_2O_3 evolution rate from the BoronPlus sources gradually decreases with continued use time. In fact, the linear relationship obtained when the data are plotted versus the square root of use time (Figure 5) indicates that the B_2O_3 is actually evolving through a diffusion-controlled process. This means that as B_2O_3 evolves from the surface of the source, a B_2O_3 concentration gradient will develop from its interior. This gradient causes additional B_2O_3 to diffuse to the surface replenishing the supply of B_2O_3 needed for continued evolution. This "reservoir" of B_2O_3 contained within the diffusion source is sufficient for many hours of use. Holding the B_2O_3 within the source instead of on its surface is also directly responsible for decreased moisture absorption from the room air between runs.

The actual lifetime of BoronPlus sources used in typical plant production environments depends upon many factors such as temperature of use, care in handling, the device being manufactured, the sensitivity of the process to the gradual decreasing evolution rate, etc. Typical use times exhibiting acceptable results of up to 500 hours near 1000˚C and up to 150 hours near 1100˚C have been reported.

■ Doping Properties of BoronPlus Sources.

A typical set of sheet resistivity versus deposition time curves for temperatures ranging from 850˚C to 1150˚C are plotted in Figure 6. Each user should determine similar sets of curves that are characteristic of their diffusion process, since these will depend somewhat on such parameters as the type of BoronPlus source being used, furnace recovery and heating/cooling rates, gas flow rates, etc.

When the various processing conditions are optimized, uniformities of 2% across the silicon, 3% across the boat, and 4% run-to-run should be attainable. Although these uniformities are generally considered to be typical of the planar diffusion system, most processors have been able to significantly improve over them.

SHEET RESISTIVITY VS. DEPOSITION TIME FOR BoronPlus SOURCES

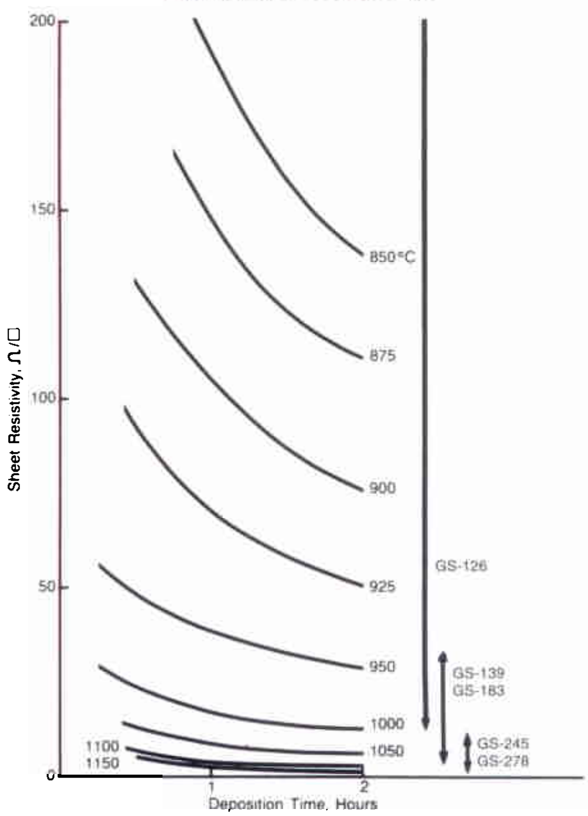
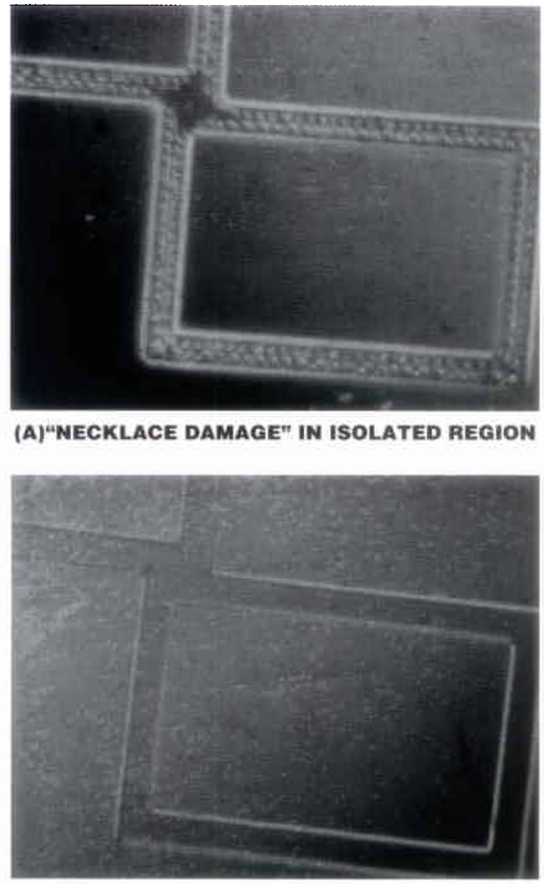


Figure 6

"NECKLACE DAMAGE" (A) IS ELIMINATED WITH BoronPlus SOURCES (B)



(A)"NECKLACE DAMAGE" IN ISOLATED REGION

(B) SIMILAR BoronPlus DIFFUSION

Figure 7(A and B)

Certain types of silicon surface damage have been reduced when BoronPlus sources are used in place of other types of dopant materials. Typical "necklace damage" shown in Figure 7(A) was eliminated as shown in Figure 7(B) when BoronPlus sources were used in a similar 1100˚C isolation predeposition cycle.

Preparing and Storing BoronPlus Sources.

The BoronPlus sources are cleaned of processing contaminants before shipping. If additional cleaning is desired, the procedures outlined in Table II should be followed.

TABLE II
CLEANING PROCEDURES

- 8 minutes in $NH_4OH/H_2O_2/H_2O(1/1/5)$ at 80˚C or 8 minutes in a megasonic cleaning system at room temperature
- 2 minutes in DI WATER
- 10 minutes DRY at 90˚C

The BoronPlus sources should not come in contact with HF or HCl at any time.

Preparation: The sources should be held at the intended deposition temperature before they are used to be sure all moisture has been removed. Although some processors begin immediately to use the sources after this initial drying period, others prefer to hold the sources at the use temperature for an additional time until a more constant B_2O_3 evolution rate occurs. The recommended minimum aging times can be obtained from Figure 8.

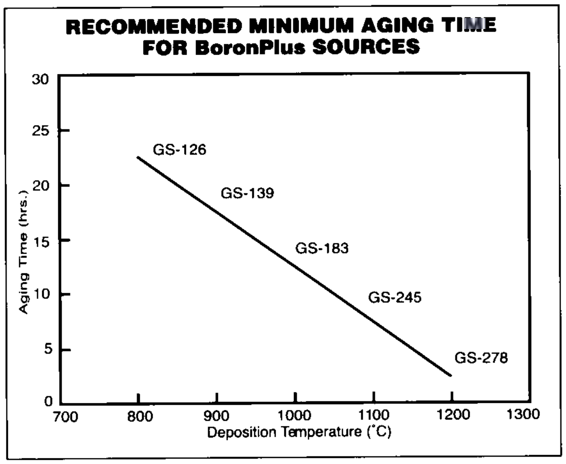


Figure 8

Storage: Since the B_2O_3 is contained within the source and not totally on its surface, the BoronPlus sources exhibit a minimum amount of water absorption. However, since absorption of even small amounts of moisture can cause problems in silicon processing, we recommend they be stored in diffusion boats in a dry environment at an elevated temperature. The best procedure is to hold the sources in the hot zone of the diffusion furnace at 600˚C in dry nitrogen.

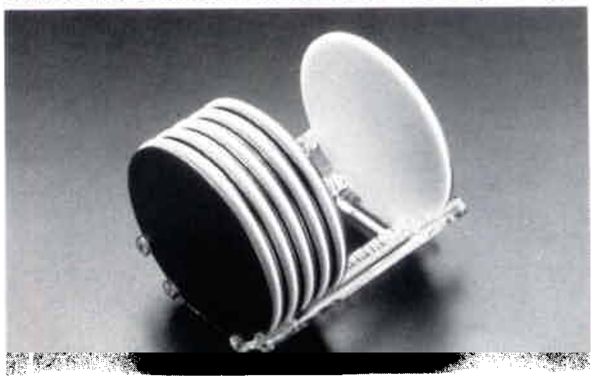


Figure 9

Typical Doping Procedures With BoronPlus Sources.

Boats: Although diffusion boats of various designs have been successfully used with the BoronPlus sources, the best results for depositions made at temperatures below about 1100˚C are normally obtained with a four-rail quartz boat with a design similar to that shown in Figure 9. When depositions are made above 1100˚C, silicon carbide or polysilicon boats are often preferred because of their increased resistance to deformation. Boats made of any of these materials fit on standard paddles and cantilever systems and can be used in automatic transfer systems. The spacing between the silicon surface and the source surface should be constant and should be between 0.060" and 0.100". The slots for the sources should be about 0.010" wider than their thickness. The sources should fit loosely in the boat, allowing room for expansion of at least 0.020" per inch of diameter.

Insertion and Removal: We recommend that a furnace ramping technique be utilized for all deposition cycles. This procedure involves slowly inserting the boatload of wafers into the diffusion tube at a temperature below about 900˚C and at least 100˚C less than the deposition temperature. After the furnace and boat have reached thermal equilibrium, the furnace is ramped to the deposition temperature. At the end of the deposition time, the furnace is cooled back to the insertion temperature, at which time the boat is withdrawn. The insertion and withdrawal rates should not be more than 4 in./min. for 100 mm sources. Because of the greater mass of material involved, slower insertion and withdrawal rates should be used with the larger diameter sources.

Ambient Gases: The BoronPlus sources can be used with the conventional gases of nitrogen and argon without detrimentally affecting their performance. Although nitrogen is the most common gas, some users prefer to use argon, especially at temperatures above 1000˚C. Small amounts of oxygen are sometimes blended with the nitrogen gas during the deposition cycle. The oxygen concentrations are usually less than 1% below 1000˚C and could be as high as 5% at deposition temperatures above 1100˚C, as shown in Figure 10. The sources should not be used in the presence of steam.

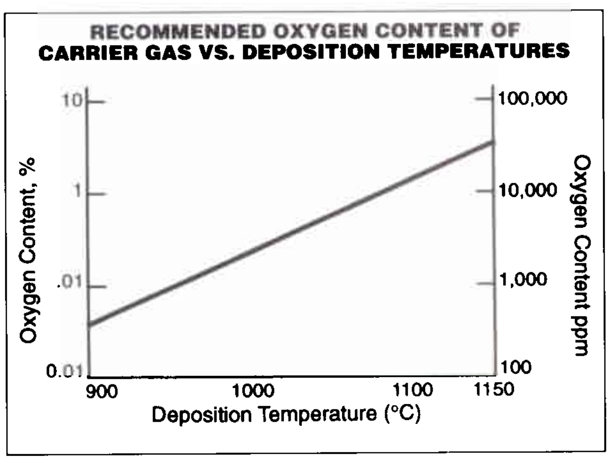


Figure 10

Low Temperature Oxidation (LTO) Cycles: High concentrations of oxygen can be used during the deposition cycle in the presence of the BoronPlus sources since oxygen has a negligible effect upon the subsequent performance of the sources. The oxygen diffuses through the deposited glassy film and oxidizes the boron-silicon phase that forms on the silicon surface during the deposition. The oxidized phase may then be easily removed with a conventional HF etch. This in-situ LTO step significantly reduces the overall processing time as schematically illustrated in Figure 11.

The in-situ LTO cycle can be used with any of the BoronPlus sources. The predictable results of using the in-situ LTO with the GS-278 BoronPlus sources for a typical p-type emitter diffusion are shown in Figure 12.

Although the in-situ LTO has been successfully used in other p-type emitter, isolation, etch stop (micromachining) and similar types of applications, the conventional low temperature oxidation cycle is usually recommended for high sheet resistivity base and source/drain diffusions because of better sheet resistivity control. A typical conventional LTO cycle is to hold the silicon wafer in steam for about 20-30 minutes near 800°C after removing the deposited glass in 10:1 HF. The sources should not be present during any LTO cycle involving steam.

Gas Flow Rates: The gas flow rate utilized during the deposition depends primarily upon the diffusion equipment such as tube size and end cap design. Although the flow rate must be high enough to prevent room air from backstreaming down the diffusion tube, flow rates ranging from as low as 2.0 l/min. to as high as 15 l/min. have been successfully used in a 135 mm diffusion tube. Satisfactory results are most often obtained with a flow rate of 3-7 l/min. for this tube size.

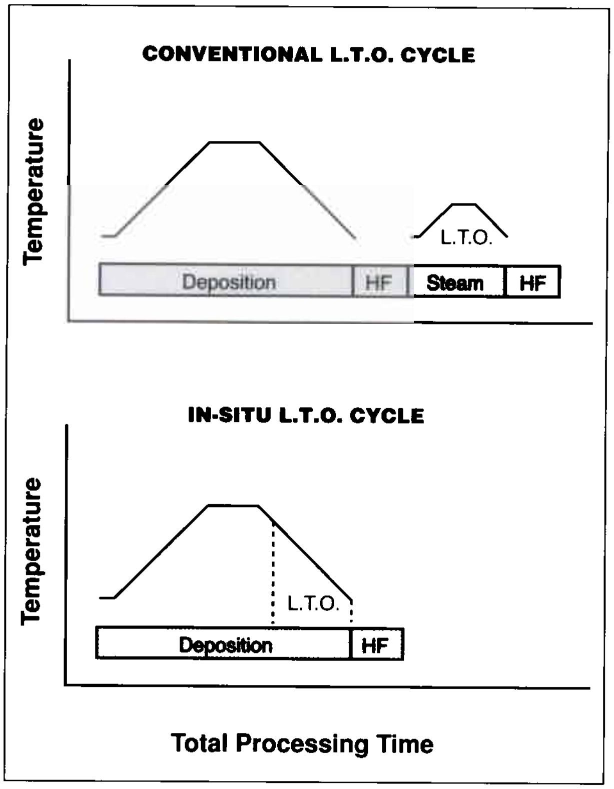


Figure 11

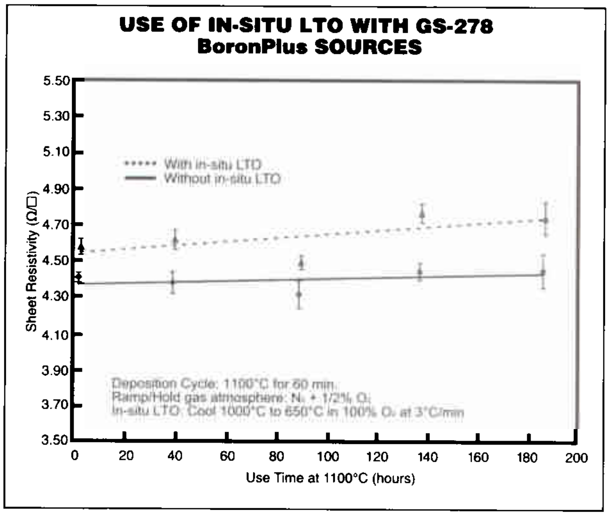


Figure 12

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