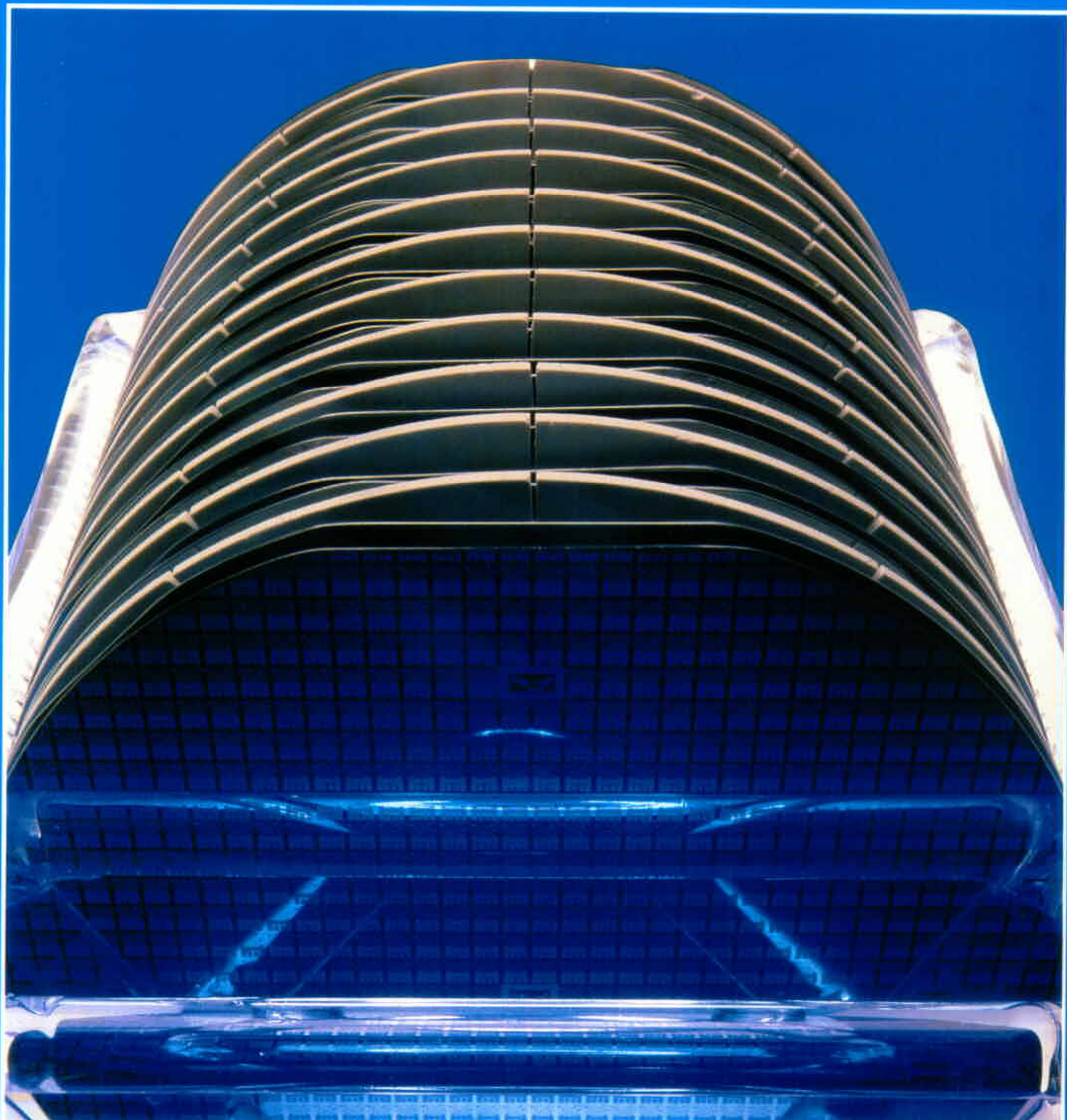
PhosPlus®

High-Purity Planar Dopant Sources



ISO CERTIFIED 9002/14001

TECHNEGLAS

PhosPlus®

Diffusion Sources:

Produce pure depositions.

- The use of high-purity raw materials results in high-purity doping of single crystal or polysilicon wafers.

Give uniform sheet resistivities.

- Uniformities typical of the planar diffusion depositions (2% across the silicon, 3% across the boat and 4% run-to-run) or better can be achieved on both single crystal and polysilicon wafers.

Exhibit long lifetimes.

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

Are safe to use.

- The sources are noncorrosive and nontoxic.

Simplify the process.

- Require no complex metering equipment commonly associated with gas and liquid dopants.
- Exhibit a minimum of water absorption.
- Need no periodic reactivation cycles.
- Can be used from 800°C to 1150°C.
- Can be removed from diffusion boats for periodic boat deglazing.
- Are compatible with many automatic transfer systems.

Minimize silicon damage.

- Many users have obtained less silicon damage on wafers doped with PhosPlus sources than other n-type diffusion techniques.
- Produce smooth polysilicon layers for double layer applications.

PhosPlus®拡散ソース

高度の拡散純度

- ソースは不純物レベルが低く、シングルクリスタル、ポリシリコンの両方で高純度拡散ができます。

高均一性のRs

- 固体ソースに典型的な均一な拡散が可能で、Si内で2%、ボート内で3%、ランツウランで4%、又はこれ以上の均一性が得られます。

長いライフタイム

- 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

- ソースは腐食性がなく、毒性もありません。

簡便な使用法

- ガスや液体ドーパントの様な、ガス流量コントロール用の複雑な装置が不要です。
- 吸湿性が極めて低くなっています。
- 定期的な再活性化処理が不要です。
- 800から1,150C°の温度で使えます。
- ボートクリーニングが簡単にできます。
- ウエーハやソース用の自動セット装置が利用できます。

低レベルのシリコンダメージ

- 他のnタイプの拡散方式にくらべ、シリコンダメージが大変低くなります。

PhosPlus

Diffusion Sources:

순수 deposition을 창출.

■ 고순도 Raw materials를 사용한 결과, Single crystal 또는 polysilicon wafer에서 고순도 doping을 생성.

sheet resistivities의 균일성.

■ 대표적인 planar diffusion deposition의 uniformities.(2% within wafer, 3% wafer to wafer, 4% run to run)또는 그이상을 single crystal 및 polysilicon wafer에서 달성.

긴 수명.

■ 많은 고객에 의해 수백시간 사용을 입증.

사용상 안전.

■ 이 source는 부식성과 독성이 없음.

공정의 단순화.

■ gas나 액체 dopants 사용에서 일반적으로 연상되는 복잡한 계량기기가 불필요.
■ 수분흡수의 최소화.
■ 주기적인 반응 cycles가 불필요.
■ 800℃에서부터 1150℃가지 사용가능.
■ 주기적인 boat의 deglazing을 위해 diffusion boat로부터 source제거 가능.
■ 많은 자동 Transfer system과 겸용.

최소의 silicon damage.

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

佳磷® 掺杂剂源

提供纯磷沉积

- 由高纯度原料制成的佳磷掺杂剂源可掺杂出得高纯度的单晶及多晶硅片.

制造均匀薄层电阻率

- 能为单晶或多晶硅片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

- 佳磷掺杂剂完全无毒性，也无腐蚀性.

应用过程简单易用

- 不需要复杂的仪表控制的装置.
- 低吸水性.
- 不需要定期的再激活过程.
- 可应用于800°C 至 1150°C.
- 于定期扩散管除玻璃程序时可由扩散管中取出.
- 可适应多种自动化操作系统.

减低硅片损坏

- 许多用户在利用佳磷掺杂源中取得比其他掺杂剂更佳的效果.

PhosPlus® 擴散磷片

高純度的擴散沉積

■PhosPlus使用了高純度的原料，因此可在單晶或多矽晶片上得到高純度的沉積.

均勻的片電阻值

■可在單晶或多矽晶片上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

■ PhosPlus無毒及無腐蝕性.

簡化製程

■不需複雜的流量控制設備，這些流量設備在氣體或液體的擴散源應用上是不可避免的.
■吸水率最小.
■不需定期的再活化處理.
■應用範圍可從800°C至1150°C.
■磷片很容易從晶舟上取下，以便晶舟的定期"去玻璃處理".
■與多數的自動轉換裝置相容.

對矽晶片的損害減至最少

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

PhosPlus® Planar Dopant Sources Have Widespread Uses.

PhosPlus planar diffusion sources represent a significant advancement in the field of phosphorus dopant materials. Their ability to easily and uniformly dope large-diameter silicon wafers in a safe manner accounts for their increasing popularity in the semiconductor industry. In general, PhosPlus sources offer all the advantages traditionally associated with planar sources plus they possess a number of additional improvements which make them the most desired phosphorus source available to the diffusion engineer.

■ Two PhosPlus Sources Provide Versatility.

Two PhosPlus sources are available to meet the many silicon processing requirements of the semiconductor industry. The following temperature ranges are normally recommended for their use:

Source Type	Recommended Temperature Range, °C	Approximate Sheet Resistivity, Ω/□
TP-470	950-1150	<1-7
TP-250	800-950	5-100

Each type of PhosPlus source contains P_2O_5 and the extremely stable oxides of Ta_2O_5, Al_2O_3 and/or La_2O_3. The sources are manufactured in such a way that the P_2O_5 is combined with Al_2O_3 or La_2O_3, and it only evolves when the sources are heated to the doping temperatures through one of the following decomposition reactions:

TP-470

$$Al(PO_3)_3 \dashrightarrow AlPO_4 + P_2O_5\uparrow$$

TP-250

$$LaP_5O_{14} \dashrightarrow LaP_3O_9 + P_2O_5\uparrow$$

Several thin radial slots are cut into the sources to ensure that they will not fracture when rapidly heated in the diffusion furnace. The slots have no effect on the uniformity of the doped silicon wafer. The TP-470 sources also contain Ta_2O_5 to adjust their thermal expansion coefficients and make them extremely resistant to thermal shock.

■ Exhibit High Purity.

The PhosPlus sources are manufactured from raw materials exhibiting very high purity. These materials are made using special processing techniques developed at TECHNEGLAS, Inc. A typical impurity analysis of a source when measured on a spark source mass spectograph is given in Table I.

■ Are Safe to Use.

PhosPlus sources are made of materials that are nontoxic, and they evolve only P_2O_5 during use. Special safety equipment and alarm systems that detect very low levels of highly toxic gases, therefore, are not required.

Table I

TYPICAL IMPURITY ANALYSIS OF PhosPlus SOURCE

Metal	PPM	Metal	PPM
Na	1	Pt	< 2
K	< 1	Rh	< 2
Li	< 1	As	< 0.2
Fe	< 2	B	< 5
Pb	< 1	Sb	< 0.5
Cr	< 2	Bi	< 0.5
Cu	< 1	V	< 1
Sn	< 1	Co	< 2
Zn	< 2	Mo	1
Ti	< 1	Ca	1
Ni	< 2	Sr	2
Ag	< 1	Mn	< 1
Au	< 0.5	Th	< 1
Ba	2	U	< 1

■ PhosPlus Sources Show Long Lifetimes.

Industrial experience has shown that PhosPlus sources normally exhibit lifetimes in the range of 100-500 use hours. The actual lifetimes of PhosPlus sources used in typical plant production, however, depend upon many factors, such as temperature of use, care in handling, device being manufactured, the sensitivity of the process to the eventual decrease in the P_2O_5 evolution rate, etc.

The potential lifetime of a PhosPlus source can be estimated by periodically doping a silicon wafer with the source being held in a diffusion furnace and observing how the resulting sheet resistivity varies with time. Figure 1 shows the average sheet resistivity obtained on the silicon wafers doped for 60 minutes at 1020°C with TP-470 sources when used in a typical production environment. Little change in sheet resistivity was observed for the first 600 hours of use. The sheet resistivity then began to slowly increase as the P_2O_5 evolution rate was gradually decreasing.

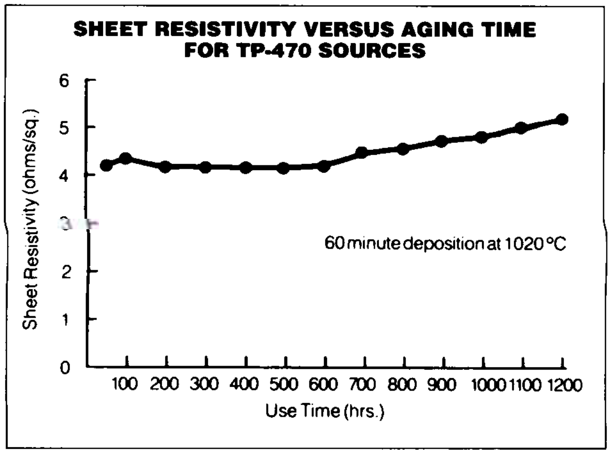


Figure 1

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A second method of estimating the lifetime of a source is to measure the amount of weight a source loses at a use temperature as the P_2O_5 evolves. Weight loss data for the TP-470 sources (Figure 2) indicate a continuing process of P_2O_5 evolution over hundreds of use hours.

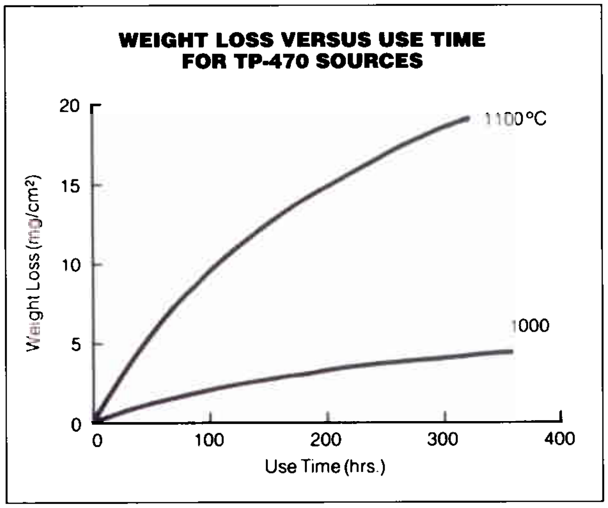

Figure 2

Figures 3 and 4 show similar sheet resistivity and weight loss data for the TP-250 sources. These data also indicate that hundreds of hours of use can be obtained from a set of TP-250 PhosPlus sources.

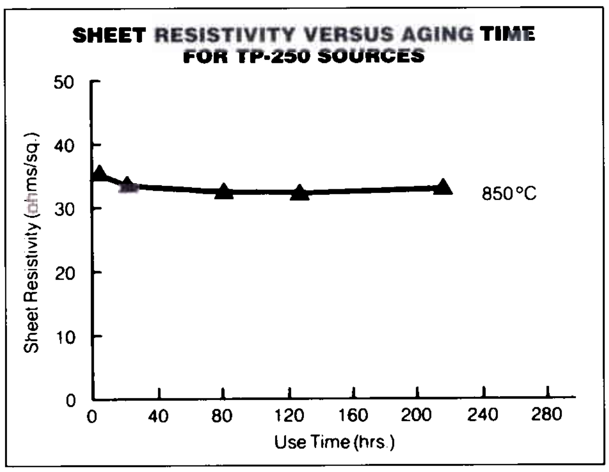

Figure 3

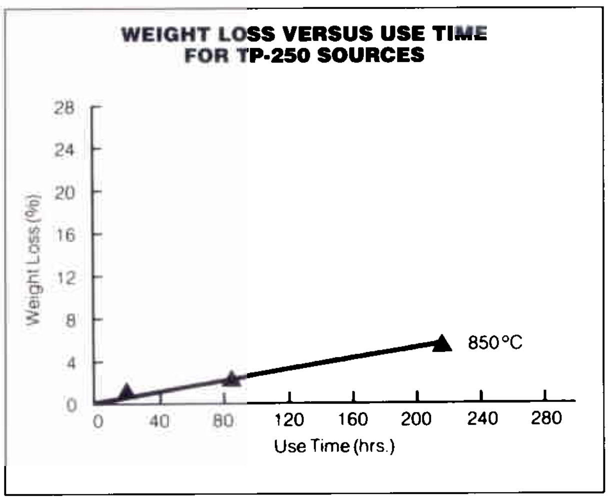

Figure 4

Doping Properties of PhosPlus Sources.

Single Crystal Silicon: Typical sheet resistivity versus deposition time curves for the two PhosPlus sources are plotted in Figures 5 and 6. The curves are different for each source because the sheet resistivity of the silicon wafer for a given deposition cycle depends somewhat upon the thickness of the deposited glassy film. The thicker the glassy film, the lower the sheet resistivity. Figure 7 shows how the deposited film thickness varies with the type of source being used.

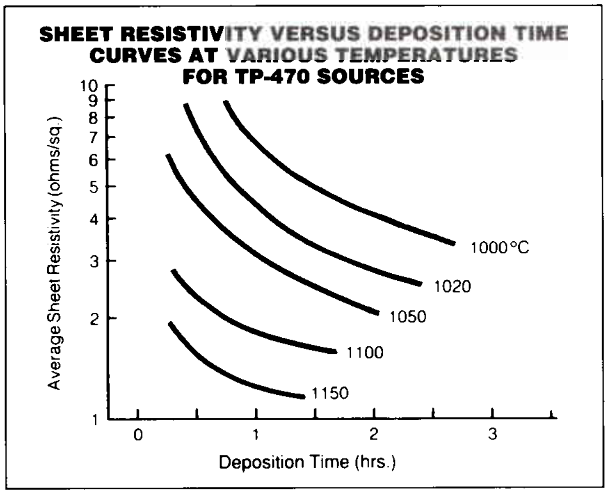

Figure 5

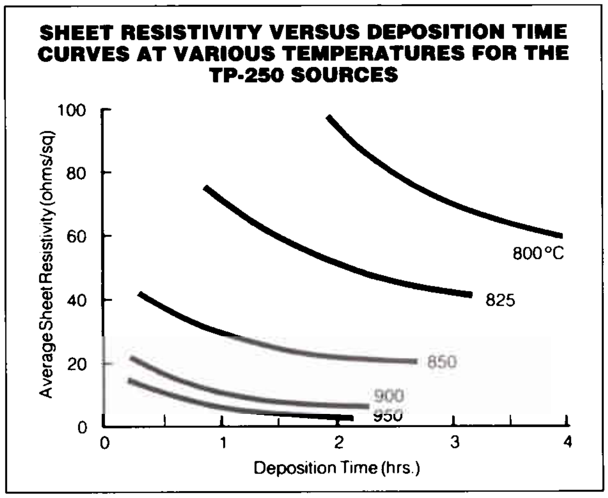

Figure 6

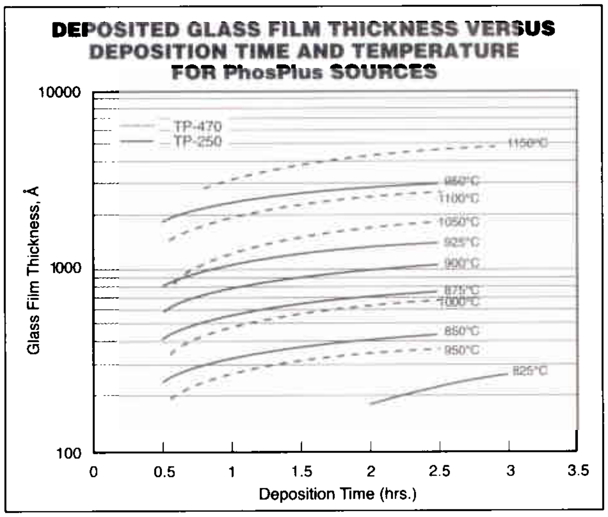

Figure 7

A typical deposition time for a solid-source diffusion system is about 45 minutes. This time is usually long enough for the sources to uniformly dope the silicon wafers. At the same time, it is short enough to be compatible with most semiconductor process parameters. Figure 8 shows the sheet resistivity and junction depth that is obtained from a 45-minute deposition with the TP-470 PhosPlus sources at various deposition temperatures.

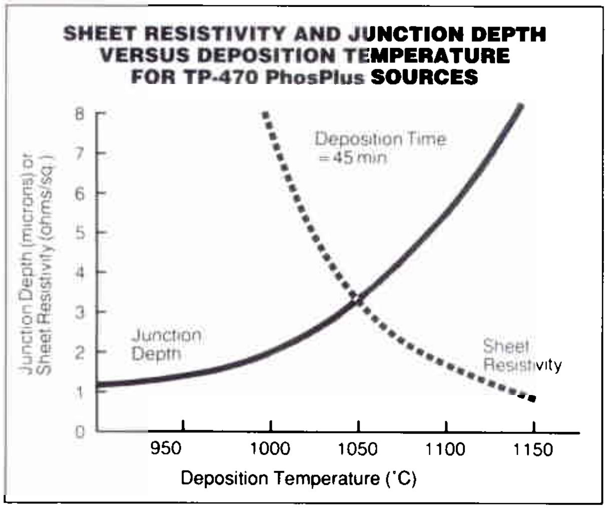

Figure 8

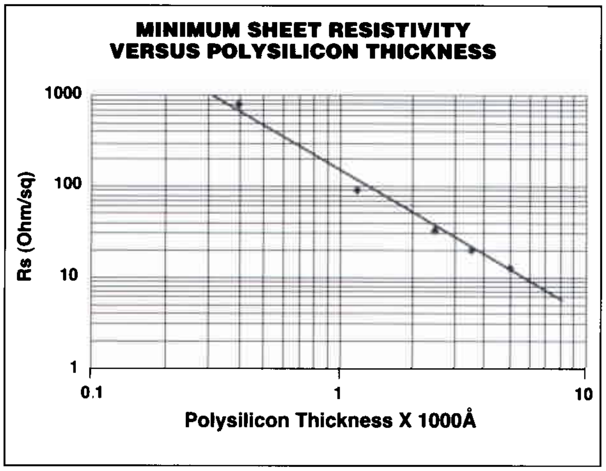

Figure 9

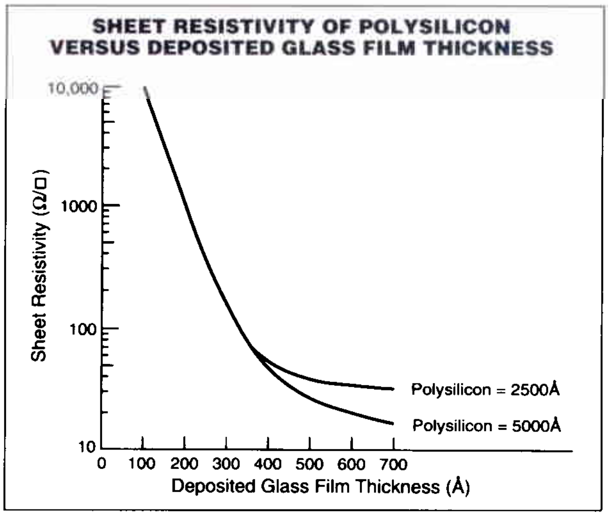

Figure 10

■ Doping Properties of PhosPlus Sources.

Polysilicon: The minimum sheet resistivity that can be obtained from polysilicon wafers that are saturated with phosphorus partially depends upon the thickness of the polysilicon layer as shown in Figure 9. These sheet resistivities are about 12 Ω/□ for 5000Å of polysilicon and about 32 Ω/□ for 2500Å, and they occur when the deposited phosphorus glassy film exceeds about 500 to 600Å as shown in Fig. 10.

Glassy films that are less than 500Å can also be uniformly deposited on the polysilicon wafers from the PhosPlus sources to produce higher sheet resistivities for special applications. Figure 10 can be used as a guide to determine the approximate thickness that is required for different sheet resistivities.

Doped polysilicon layers with smooth surfaces are important in the manufacture of certain devices. Very smooth surfaces can be obtained when the polysilicon layer is first doped with the TP-250 sources to a level slightly below saturation (400-500Å as shown in Fig. 10.). When this glass is etched off and the silicon wafers are annealed near 950°C for about 15 min, smooth surfaces are maintained and the silicon exhibits the minimum sheet resistivity characteristic of its thickness (Fig. 9).

Sheet resistivities at or above the saturation of phosphorus in polysilicon can be obtained from either phosphorus source. The appropriate deposition cycle can be selected from the curves shown in Figures 11 and 12.

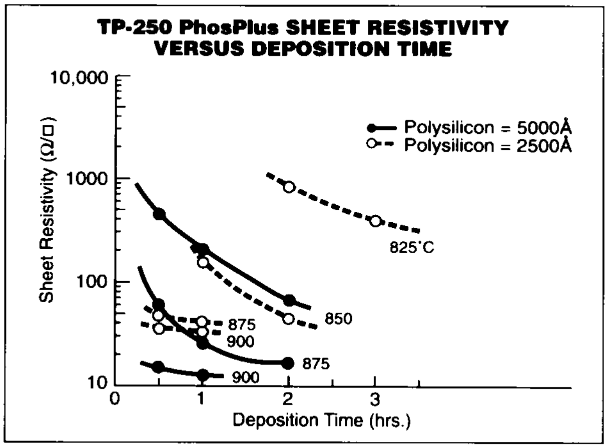

Figure 11

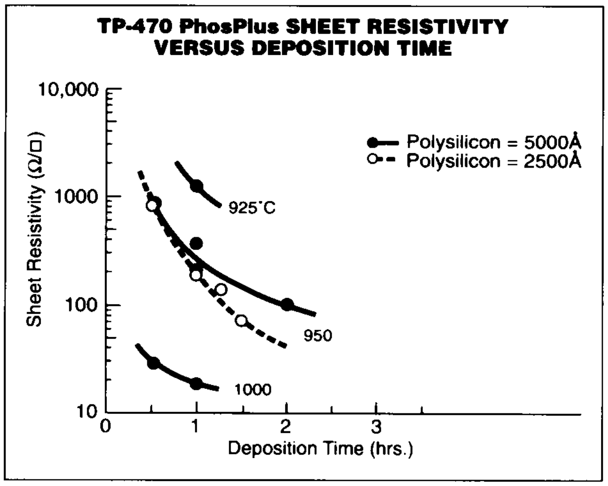

Figure 12

■ Doping Properties of PhosPlus Sources.

Uniformities: When the various processing conditions are optimized, uniformities of 2% across the silicon, 3% across the boat and 4% run-to-run or better can generally be obtained on single-crystal silicon. A total variation of about 3% can be achieved on high-quality polysilicon wafers doped to their minimum sheet resistivities (saturation with phosphorus).

These uniformities are quite typical of the planar diffusion system and tend to be independent of the diameter of the wafer and the number of silicon wafers being processed during a run. This independence can result in an increase in silicon throughput compared to the number of silicon wafers often processed in gas systems. It can also significantly increase production yields by improving process control as demonstrated by the decrease in beta variation when TP-470 PhosPlus sources are used for an emitter diffusion instead of $POCl_3$ (Figure 13).

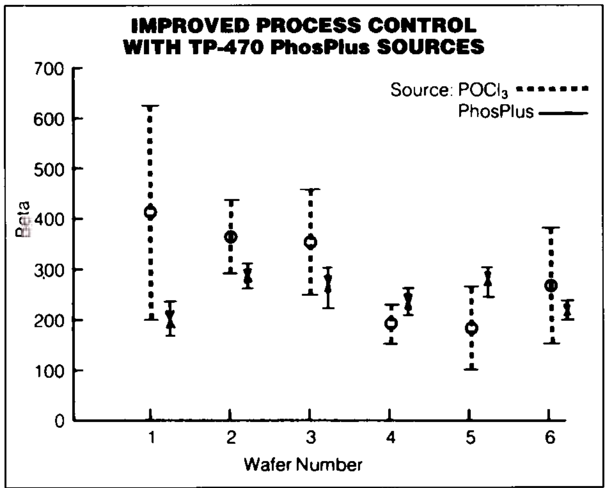

Figure 13

TABLE II CLEANING PROCEDURES
15 seconds dilute acid at room temperature: TP-250 4:1 HNO_3 TP-470 10:1 HF 2 minute rinse in fresh DI water. 1 minute rinse in fresh DI water. Hold in a clean hood until dry. Store in nitrogen.
This procedure is only recommended for **initial** cleaning. If the sources become contaminated after use, contact your area technical representative for assistance.

■ Preparing and Storing PhosPlus Sources:

Cleaning: As part of the routine cleaning process, the PhosPlus sources are acid etched to remove any foreign matter and to expose a pristine surface. As a result, no additional cleaning is necessary before putting the sources into the diffusion furnace. If additional cleaning is desired, the procedure in Table II is the only one recommended.

Preparation: Before using the PhosPlus sources in production for the first time, they should be held at the intended deposition temperature for a period of time. This will ensure that all moisture has been vaporized, and it enables the sources to achieve a constant P_2O_5 evolution rate. The aging period may last from a few hours for high temperature processes to as long as 24 hours for low temperature processes. Figure 14 gives the recommended minimum aging times for the two PhosPlus sources.

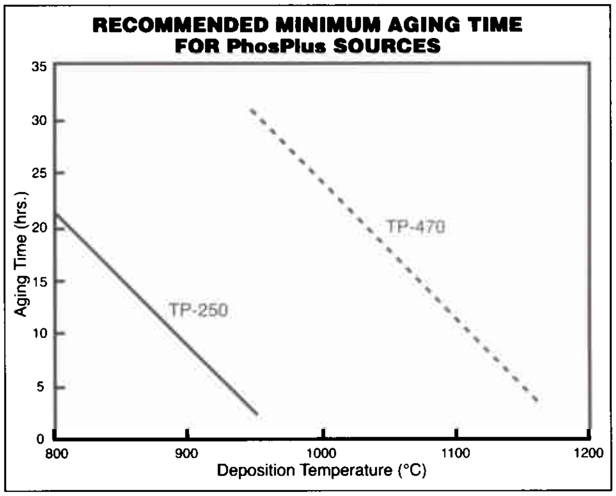

Figure 14

Storage: Since the phosphorus is present within the sources in the form of a complex crystal and not as the extremely hygroscopic P_2O_5 material, the PhosPlus sources exhibit a minimum amount of water absorption. However, the absorption of even small amounts of moisture can cause various problems in silicon processing. It is therefore recommended that the sources be stored in the diffusion boats in nitrogen at an elevated temperature when the time between runs exceeds about 45 minutes. If the sources were accidently left out in a room for a long period of time, however, they can be quickly prepared for the next run by merely inserting them into the diffusion tube at the insertion temperature for about 15 minutes. When they are withdrawn from the tube, the boat is ready for loading with production silicon.

Typical Doping Procedures with PhosPlus Sources.

Boats: Although diffusion boats of various designs have been successfully used with the PhosPlus sources, the best results are normally obtained with a four-rail quartz boat having a design as shown in Figure 15. 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 0.010" per inch of diameter.

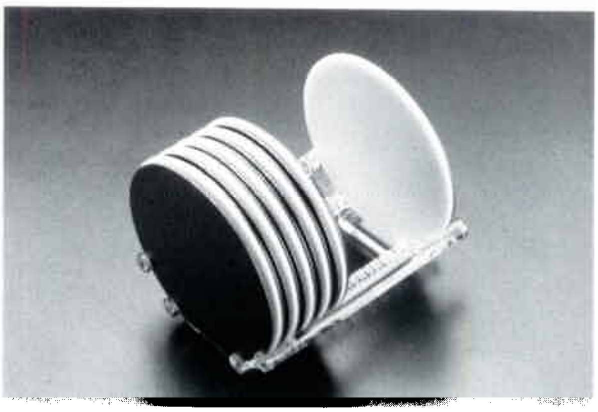

Figure 15

Insertion and Removal: A furnace ramping technique should be utilized for all deposition cycles. This procedure involves slowly inserting the boatload of wafers into the diffusion tube at a temperature below about 800˚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: Either of the two PhosPlus sources can be used with the conventional gases of nitrogen or argon without detrimentally affecting their doping performance. Although oxygen does not adversely affect the sources, too high of an oxygen concentration should be avoided because of the potential for masking off the silicon surface to be doped. Steam should also be avoided in the presence of the PhosPlus sources at the deposition temperature. Steam causes the P_2O_5 to rapidly evolve from the sources resulting in shorter lifetimes of the sources.

When using the TP-470 sources above 1000˚C, small quantities of oxygen may be blended with the nitrogen or argon. The oxygen concentration in the carrier gas is usually less than 1% below 1050˚C and could be as high as 5% at temperatures above 1100˚C.

When the TP-250 sources are used near 900˚C, the oxygen concentration should be maintained below about 1%. This concentration may be increased up to about 5% when depositions are made at higher temperatures. No oxygen should be used below about 875˚C, especially when polysilicon layers are being doped.

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.