PDS® Products

Planar Diffusion Sources

Furnace Carriers for PDS® Products in Diffusion Processing

GENERAL OVERVIEW

In the PDS® Products diffusion system the furnace carriers used differ in several respects from those used with other systems. To realize all the advantages and capabilities of the planar source system, carrier design must take these differences into account.

SYSTEM DESCRIPTION

The PDS Products diffusion system is similar to so-called carrier-gas systems in that it requires separate pre-deopsition and drive-in operations and uses the same or similar diffusion furnaces. It differs, however, and is vastly simplified in that the sources are “in-situ” i.e., are interspersed in the same pre-deposition furnace carriers (hereafter called “source boats”) with the silicon being diffused. Therefore, carrier gases are not needed to distribute (carry) the diffusants. With no carrier gases, there is no turbulence problems and no positional dependency of silicon wafers. Silicon loading density and furnace throughput can be greatly increased.

STACKING ARRANGMENT

For pre-deposition, silicon and source wafers are edge-stacked in the same source boat, their faces perpendicular to the tube axis and parallel to each other and with a source wafer adjacent to the face of each silicon waferas shown in Figures 1 A & B. Typical loading of the furnace carrier begins with a source wafer followed by two silicon wafers back-to-back followed by another source wafer, etc., ending with a final source wafer at the opposite end of the carrier. This allows most of the source wafers to dope two silicon wafers.

Quartz polysilicon and silicon carbide furnace carriers are all used with the PDS Products system. Those with the lowest thermal masses usually produce the best uniformities.

Source wafers are typically spaced 0.100” to 0.141” (center-to-center) from the silicon. The silicon wafers are usually 0.060” to 0.094” (center-to-center). Spacing will depend upon the style of wafer carrier used.

The PDS Products system will readily accept a wide range of wafer spacing such as those required to accommodate different makes of automated wafer transfer systems.

The PDS Products system does not use a carrier gas for dopant transport, as there is a source directly adjacent to the surface of each silicon wafer to be diffused. However, a flow of inert gas, usually nitrogen, is used to purge room air from the diffusion tube and to ensure a formation of a boundary layer around the periphery of the stacked source and silicon wafers.

Figure 1A: Stacking Arrangement for Boron Nitride Grade PDS Products

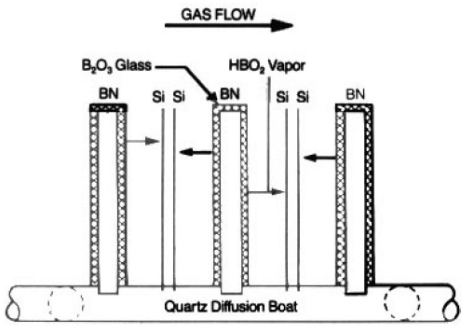
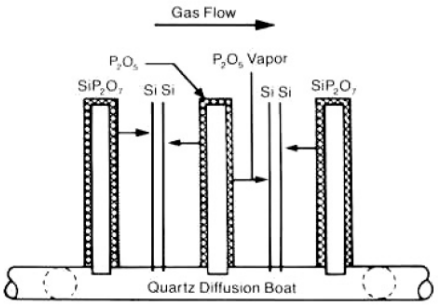


Figure 1B: Stacking Arrangement for Phosphorus Nitride Grade PDS Products



No capital expense is required to convert a diffusion furnace from a carrier gas system to the PDS PRODUCTS system. Additionally, PDS Products eliminate maintenance costs associated with “sticky” furnace tubes, controller valves and regulators used with the carrier gas systems.

The dopant vapor is transported the short distance to the silicon surfaces by concentration gradient diffusion through the ambient gas (Fick’s Law). By following recommendations, the PDS Products system can produce typical sheet resistance uniformity of ±1% across individual silicon wafers and ±2% across the furnace flat zone, regardless of wafer diameter.

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PRE-DEPOSITION

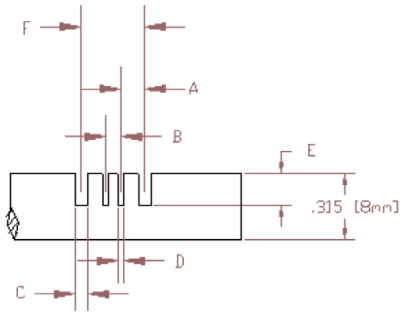
During pre-deposition, vaporized glasses of conventional compositions, e.g., B_2O_3, HB_2O_3 or P_2O_5, are released from the source wafers at rates controlled by furnace temperature, and in cumulative amounts controlled entirely by time. The vaporized glasses move spontaneously across the small spaces separating the source and adjacent silicon wafers, condensing uniformly on all silicon wafers in the source boat.

DIFFUSION CARRIER DESIGN AND MATERIAL

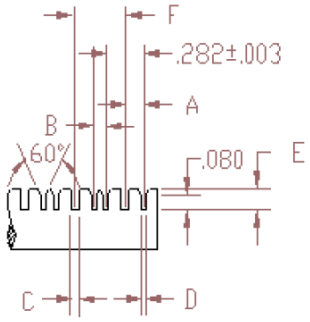
FUniformity of results depends largely on the design and construction of the source boats. PDS Products optimum performance is best obtained with the use of Contiguous and Manual 3 or 4 rail quartz carriers. For high temperatures, Carrier material may be Silicon Carbide or polysilicon. Material selection will depend upon the application.

Source and silicon wafers must be held parallel to each other, without touching, and spacing must be uniform throughout the boat. Recommendations for PDS Products Solid Source and silicon wafer spacing may be found at **www.mgiproducts.com** or **www.mactronix.com**.

Wafer Slot Arrangement and Dimensions: Manual Carrier



Wafer Slot Arrangement and Dimensions: Contiguous Carrier



Dimensions, center to center

Manual Carrier :

Part Number	Wafer Diameter		PDS - Si A		Si - Si B		PDS Slot C		Si Slot D		Slot Depth E		PDS-PDS F	
			inches	mm	inches	mm	inches	mm	inches	mm	inches	mm	inches	mm
P- Type														
MQC-20042-P	2"	50.8 mm	0.100	2.54	0.060	1.524	0.043	1.09	0.022	0.5588	0.125	3.175	0.260	6.60
MQC-30042-P	3"	76.2 mm	0.100	2.54	0.060	1.524	0.043	1.09	0.022	0.5588	0.125	3.175	0.260	6.60
MQC-39452-P	3.94"	100 mm	0.125	3.175	0.080	2.032	0.053	1.35	0.032	0.8128	0.150	3.81	0.330	8.38
MQC-40052-P	4"	101 mm	0.125	3.175	0.080	2.032	0.053	1.35	0.032	0.8128	0.150	3.81	0.330	8.38
MQC-49252-P	4.92"	125 mm	0.125	3.175	0.080	2.032	0.053	1.35	0.032	0.8128	0.150	3.81	0.330	8.38
MQC-49262-P	4.92"	125 mm	0.125	3.175	0.080	2.032	0.063	1.60	0.032	0.8128	0.150	3.81	0.330	8.38
MQC-59162-P	5.91"	150 mm	0.150	3.81	0.100	2.54	0.060	1.52	0.032	0.8128	0.150	3.81	0.400	10.16
MQC-59172-P	5.91"	150 mm	0.150	3.81	0.100	2.54	0.070	1.78	0.032	0.8128	0.150	3.81	0.400	10.16
N- Type														
MQC-20062-N	2"	50.8 mm	0.100	2.54	0.060	1.524	0.063	1.60	0.022	0.5588	0.100	2.54	0.260	6.60
MQC-30062-N	3"	76.2 mm	0.100	2.54	0.060	1.524	0.063	1.60	0.022	0.5588	0.100	2.54	0.260	6.60
MQC-39462-N	3.94"	100 mm	0.125	3.175	0.080	2.032	0.063	1.60	0.032	0.8128	0.150	3.81	0.330	8.38
MQC-40062-N	4"	101 mm	0.125	3.175	0.080	2.032	0.063	1.60	0.032	0.8128	0.150	3.81	0.330	8.38
MQC-49262-N	4.92"	125 mm	0.125	3.175	0.080	2.032	0.063	1.60	0.032	0.8128	0.150	3.81	0.330	8.38
MQC-59162-N	5.91"	150 mm	0.150	3.81	0.100	2.54	0.063	1.60	0.032	0.8128	0.150	3.81	0.400	10.16

Contiguous Carrier :

Part Number	Wafer Diameter		PDS - Si A		Si - Si B		PDS Slot C		Si Slot D		Slot Depth E		PDS-PDS F	
			inches	mm	inches	mm	inches	mm	inches	mm	inches	mm	inches	mm
P- Type														
CQC-49252-P	4.92"	125 mm	0.141	3.58	0.093	2.63	0.053	1.35	0.036	0.91	0.12	3.05	0.375	9.53
CQC-49262-P	4.92"	125 mm	0.141	3.58	0.093	2.63	0.063	1.60	0.036	0.91	0.12	3.05	0.375	9.53
CQC-59162-P	5.91"	150 mm	0.141	3.58	0.093	2.63	0.063	1.60	0.036	0.91	0.12	3.05	0.375	9.53
CQC-59172-P	5.91"	150 mm	0.141	3.58	0.093	2.63	0.073	1.85	0.036	0.91	0.12	3.05	0.375	9.53
CQC-78762-P	7.87"	200 mm	0.141	3.58	0.093	2.63	0.063	1.60	0.036	0.91	0.12	3.05	0.375	9.53
CQC-78772-P	7.87"	200 mm	0.141	3.58	0.093	2.63	0.073	1.85	0.036	0.91	0.12	3.05	0.375	9.53
N- Type														
CQC-49262-N	4.92"	125 mm	0.141	3.58	0.093	2.63	0.063	1.60	0.036	0.91	0.12	3.05	0.375	9.53
CQC-59162-N	5.91"	150 mm	0.141	3.58	0.093	2.63	0.063	1.60	0.036	0.91	0.12	3.05	0.375	9.53
CQC-78762-N	7.87"	200 mm	0.141	3.58	0.093	2.63	0.063	1.60	0.036	0.91	0.12	3.05	0.375	9.53

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GASES AND FLOW RATES

A tight fitting end cap or plate should be used on the furnace (see Figures 2A and 2B). To achieve good uniformity in all furnace processes, the process tube and wafer carrier should be centered so they are concentric with the furnace coils. By centering the wafers, the temperature gradient across them is usually minimized, allowing for more uniform diffusion and oxidation. This compact stacking arrangement allows for increased furnace utilization. Consequently, PDS PRODUCTS wafers can be used with automated transfer systems, which help to increase yields.

The process ambient is usually N_2 unless the process makes use of hydrogen injection in which a mixed ambient of N_2, H_2 and O_2 is used. With hydrogen injection, the effect of background moisture is significantly diminished with the addition of a small amount of H_2O vapor to the ambient. Details on this process are given in the "Low Defect Boron Diffusion Processes Using Hydrogen Injection" Technical Bulletin.

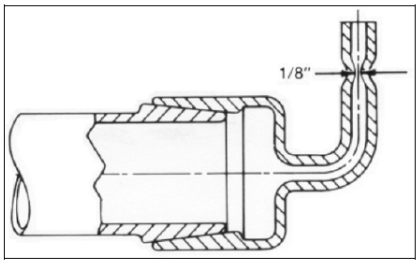

Figure 2A: Recommended End Cap Design – Manual Push-Pull Systems

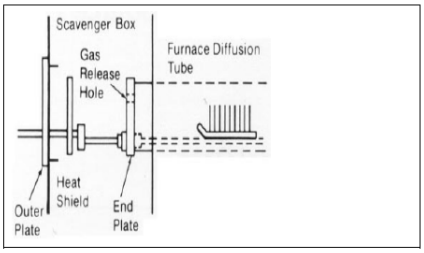

Figure 2A: Typical Automatic Push-Pull System with End Plate

RECOMMENDED GAS FLOW RANGES FOR PDS® PRODUCTS IN DIFFUSION PROCESSING

Table shows recommended total gas flow for various wafer sizes and tube diameters. These gas flows should be used as a starting point for Planar Diffusion Source evaluations.

1. Dry BN processing and N-Type processing should use the low range value of total gas flows as the starting point.
2. Note that the total gas flow depends greatly on the end-cap design and could vary from the recommended total gas flow by as much as 50%.
3. Gas flow can be optimized by making a plot of uniformity vs total gas flow. Optimal gas flow results in best uniformity.

Wafer Size	Tube I.D.	Aea Difference (mm^2)	Gas Flow (slpm)
3"	101mm	3452	1.0 - 3.0
3"	135mm	9754	4.0 - 8.0
3"	160mm	15546	6.0 - 10.0
100mm	135mm	6460	2.0 - 5.0
100mm	160mm	12252	6.0 - 10.0
100mm	185mm	19026	8.0 - 14.0
125mm	160mm	7834	6.0 - 10.0
125mm	185mm	14608	8.0 - 12.0
125mm	200mm	19144	8.0 - 14.0
150mm	185mm	9209	6.0 - 10.0
150mm	200mm	13745	8.0 - 12.0
150mm	235mm	25702	16.0 - 20.0
200mm	235mm	11958	8.0 - 12.0
200mm	260mm	21677	16.0 - 20.0
200mm	285mm	32378	25.0 - 30.0

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

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