BoronPlus®

Product Bulletin 310

Solid Diffusion Sources

Moisture-Enhanced Evolution Rate Process Using GS-126 BoronPlus® Sources

Introduction

The GS-126 p-type boron planar dopant source exhibits all of the desirable properties of the other BoronPlus sources. However, this source is specifically designed to be used at temperatures below 1000°C, with or without low levels of moisture being present in the nitrogen carrier gas.

How the process works

GS-126 sources uniformly deposit thin glassy films on the silicon wafers when used with conventional processing techniques in dry nitrogen. However, film thicknesses can be significantly increased if depositions are made in nitrogen containing controlled amounts of hydrogen and oxygen. When these gases are blended into the carrier gas, the hydrogen combines first with the oxygen to form H_20 which then reacts with B_2O_3 to form $HB0_2$. Since HBO_2 exhibits a much higher vapor pressure than B_2O_3, HBO_2 evolves from the source at a significantly higher rate than B_2O_3 and produces a thicker glassy film on the silicon wafer.

The thicker glassy films help to improve the uniformity of doping at low temperatures and tend to produce an increase in the thickness of the boron-silicon phase that forms under the deposited glass. When the silicon wafers are deglazed and given a low temperature oxidation cycle, most of the silicon surface damage is removed with the oxidized boron-silicon phase.

Required Equipment

Small quantities of hydrogen and oxygen can be easily and accurately blended into the nitrogen carrier gas in a production environment by using a mass flow controller system. An oxygen concentration of 500 ppm should be maintained for all depositions made between 850° and 900°C. The hydrogen flow rate is then used to control the theoretical moisture concentration forming in the diffusion tube.

Figure 1 shows the hydrogen flow rates theoretically required to create various moisture levels in nitrogen. To accurately control these low hydrogen flow rates, use of preblended hydrogen in nitrogen is recommended. The flow rates are low enough that one standard tank can be used for hundreds of runs. Table 1 gives typical flow rates for various hydrogen/nitrogen mixtures when nitrogen is flowing at 3 liters per minute. Proportional adjustments to these flow rates can be made for other nitrogen flow rates.

Figure 1
Hydrogen Flow Rates Required to Create Various Moisture Levels

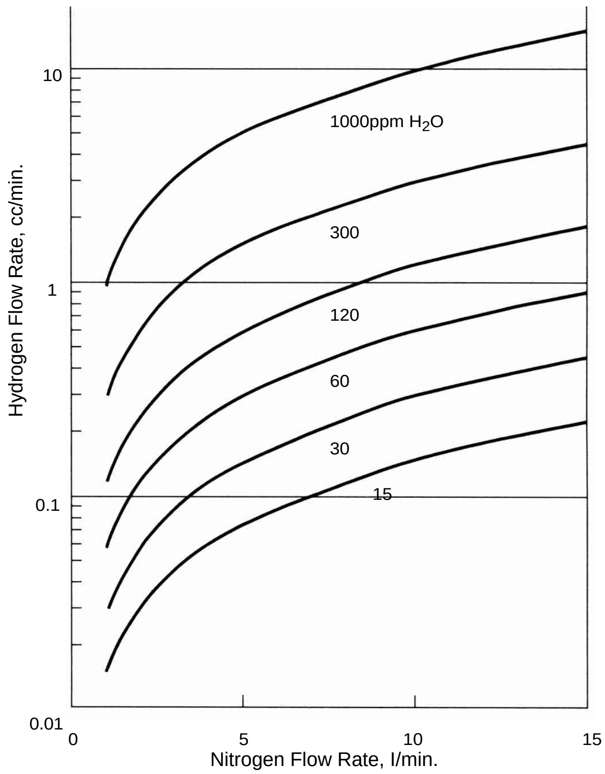


Table 1
Flow Rates When N_2 = 3 liters/minute.

H_20	10%H_2, 90%N_2	5%H_2, 95%N_2	1%H_2, 99%N_2
15 ppm	0.45 cc/min.	0.9 cc/min.	4.5 cc/min.
60 ppm	1.8 cc/min.	3.6 cc/min.	18 cc/min.
120 ppm	3.6 cc/min.	7.2 cc/min.	36 cc/min.

Deposition Cycle

A typical deposition cycle is schematically represented in Figure 2.

Figure 2
Typical Moisture-Enhanced Deposition Cycle

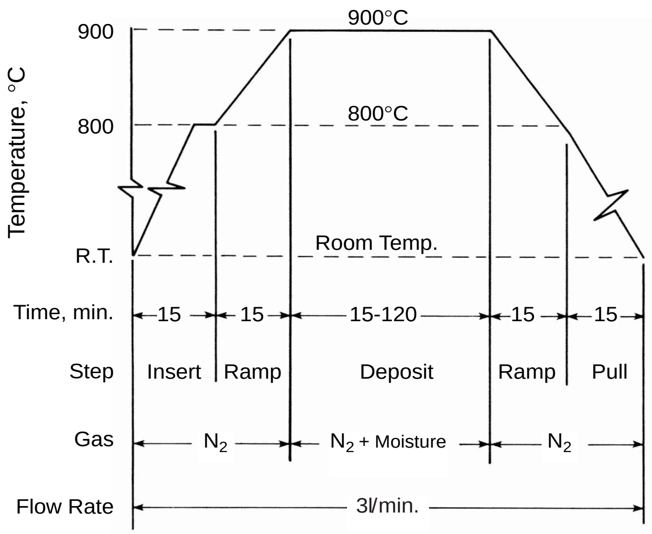


Table II shows maximum moisture levels recommended for depositions made at 850° and 900°C. Since higher levels exceed the rate at which the source can evolve HBO_2 they do not produce thicker glassy films.

Table II
Maximum Moisture Content for Optimum Doping

800°C	30 ppm
900°C	120 ppm

Effect of Moisture on Boron Depositions

Figures 3 and 4 show the deposited glassy film thickness as a function of theoretical moisture content forming in the diffusion tube at 850°C and 900°C using the deposition cycle shown in Figure 2. These figures also show resulting sheet resistivity in the silicon under the deposited glass.

Figure 3
Depositions in Moisture at 850°C

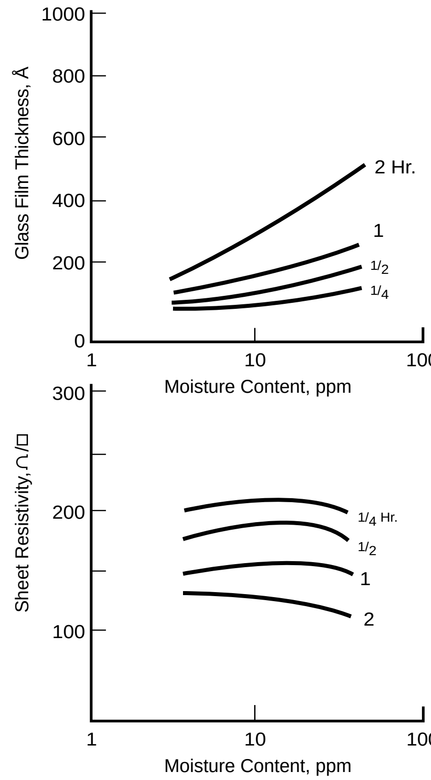


Figure 4
Depositions in Moisture at 900°C

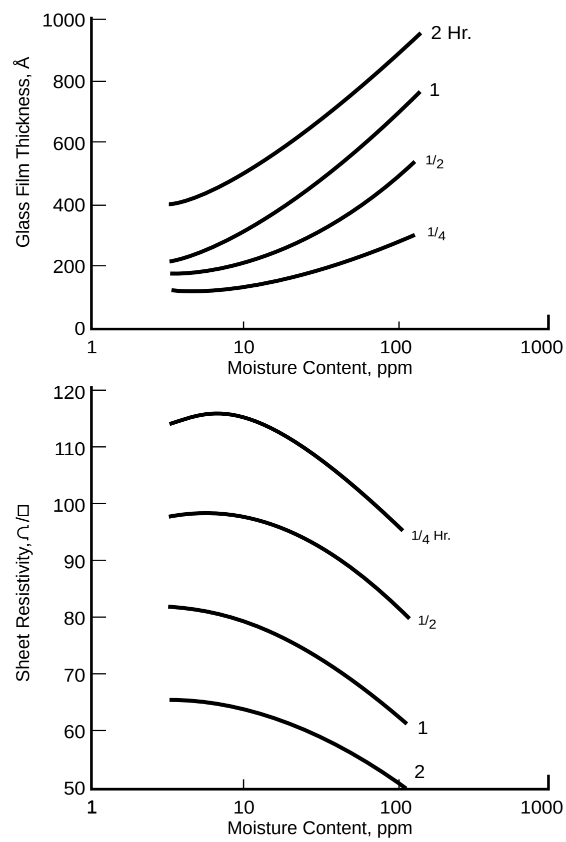
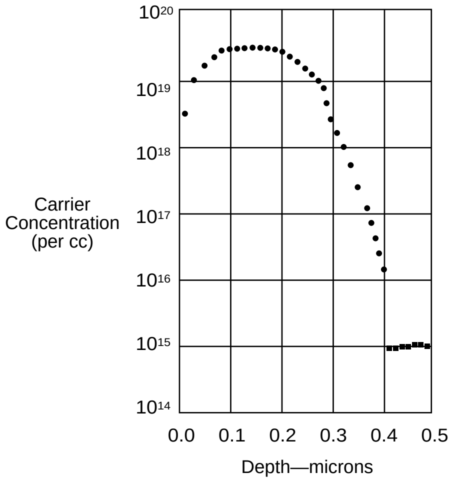
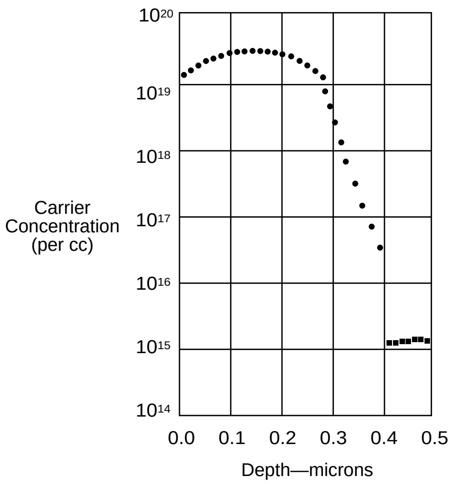


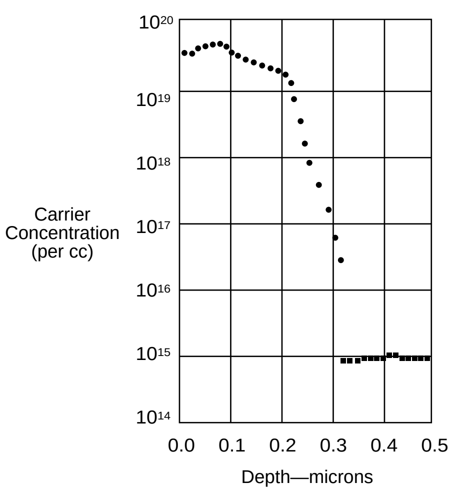
Figure 5
SRP Measurements on Doped Silicon Slices
A) 900°C for 70 Min. in Dry N_2



B) 900°C for 45 Min. in N_2 + 15 ppm H_20



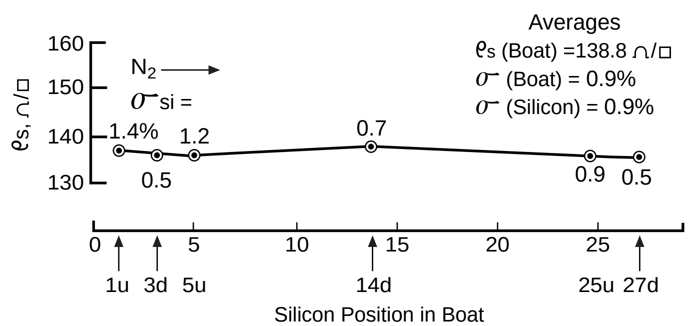
C) 900°C for 25 Min. in N_2 + 60 ppm H_20



A few selected spreading resistance curves measured on the doped silicon are shown in Figure 5. The silicon slices were first deglazed and then given an 800°C for 20 minutes low temperature oxidation cycle in steam to remove the boron-silicon phase before the dopant concentration profile curves were made.

Figure 6 shows results of doping 10 micron wide resistor bars on 100mm silicon wafers at 900°C for 30 minutes using 30 ppm H_20 in nitrogen gas. Variations of less than 1% across the boat and across the silicon are comparable to those normally obtained from silicon wafers doped with ion implanters.

Figure 6
Results of Doping 100mm Silicon Wafers
900°C for 30 Min. in N_2 + 30 ppm H_20



u/d = silicon facing upstream/downstream

A process has been developed which permits the use of GS-126 BoronPlus sources in the presence of a controlled amount of moisture. The process is easy and safe to use and it gives the process engineer more flexibility in selecting the thickness of glass being deposited on the silicon wafers. Uniformity of doping approaching that of ion implantation can be obtained with less silicon damage, without dopant channeling and at reduced costs.

For more information on this doping technique and how it can be easily made to fit into your current production process, contact the Planar Dopants Team: www.techneglas.com