BoronPlus®

Product Bulletin 512B

Solid Diffusion Sources

(Formerly PB 412)

Source Preparation: Cleaning

Introduction

A successful production of semiconductor devices requires that the silicon wafers, boats, paddles, tubes, etc. be carefully cleaned of all contaminates before they are used. Usually these materials are cleaned with one of the procedures that have become somewhat standard in the semiconductor industry. However, if the procedure is found to have a deleterious effect on the performance of the material, some alternate cleaning procedure must be used. This is the case for the BoronPlus sources.

This bulletin gives recommended procedures on how to clean the BoronPlus sources. It also gives cautions on alternate cleaning solutions and procedures that may harm the sources.

Cleaning Procedures

The BoronPlus sources are cleaned of processing contaminates before shipping. If additional cleaning is desired, however, the following procedure, which is similar to the SC1 portion of the "RCA Standard Clean" [1], can be used on any BoronPlus source:

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 100°C

The following cleaning procedure cannot be used on the GS126 sources, but it could be used on the other BoronPlus sources if desired:

2 minutes in HNO_3/H_2O (1/20)

2 minutes in DI Water #1

1 minute in DI Water #2

30 seconds in Acetone

10 minutes dry in a clean hood

After the cleaning process is complete, the sources should be inserted into the diffusion furnace to begin the aging cycle using the procedures outlined in Product Bulletin 511. The aging cycle insures that the BoronPlus sources are evolving B_2O_3 at a uniform rate, that all moisture is vaporized and that any residual cutting and cleaning solutions are oxidized.

Removal of "Black Spots"

When a BoronPlus source is initially fired in the diffusion furnace, a few "black spots" may occasionally show up on its surface. These spots have been found to be harmless, but they can be removed if desired by following certain steps in the preparation of the sources.

The "black spots" actually originate early in the manufacturing process of the BoronPlus sources. This is because the sources are made from a relatively unstable glass composition which may permit several large crystals to grow within the billet during the casting and heat treating steps. These crystals cannot be seen before the billets are cut because the material is opaque. However, if the saw blade happens to cut through one of the crystals during the slicing operation, the crystal will absorb some of the cutting fluid. Since this cutting fluid cannot be totally removed from the crystal with any of the cleaning processes, it will eventually turn to carbon when the sources are inserted into the diffusion furnace. The residual carbon makes the crystal appear as a "black spot" in the wafer. On the other hand, if the crystals do not touch the cut surface, the cutting fluid is not absorbed, and the crystals remain, in this case, as "white spots" when fired.

Before the sources are used to dope silicon wafers, they are inserted into the diffusion furnace in 25% oxygen for a period of time. This aging cycle usually turns the "black spots" into "white spots" because the oxygen in the carrier gas diffuses into the crystals and oxidizes the carbon. The crystals themselves, however, do not disappear since they can still be seen in the wafer when examined under transmitted light.

Extensive testing has been done to determine if these crystals would have any effect upon devices being manufactured across from them [2]. After measuring a number of sensitive electrical properties of 1700 diodes, it was concluded that the properties of the diodes located across from the crystals were not significantly different than the properties of the diodes located across from other portions of the sources. The results of the tests were the same whether the sources were used at 975°C or at 1075°C, whether the crystals were black or white, and whether the sources were new or had been used for hundreds of hours. It is therefore concluded that the spots in the sources, white or black, are merely cosmetic in nature and should not be a reason for any serious concern.

Alternate Cleaning Solutions

The BoronPlus sources were cleaned in a number of organic and inorganic cleaning solutions and were then tested to see if the solutions had any effect on their doping characteristics. The organic solutions that had little or no effect on the doping characteristics were acetone, freon, heptane, xylene, butyl alcohol, and isopropyl alcohol. The only inorganic solvents that did not affect the doping characteristics, however, were HNO_3 (dilute) and the SC1 clean when used as described above. HF, HCl and H_2SO_4 in concentrations of 1:1 to 10:1 all reacted negatively with the sources and in some cases completely stopped all B_2O_3 from evolving from them.

The BoronPlus sources that were cleaned in very dilute HF (40:1) initially showed a decrease in B_2O_3 evolution rate, but the sources eventually recovered after aging and began evolving B_2O_3 at a normal rate. Consequently, in the event of a serious contamination where the impurity is not loose on the surface but is actually imbedded into the surface of the source (i.e. by diffusion), cleaning the sources for a few minutes in this dilute solution of HF might be an effective way to remove the impurity. However, this cleaning procedure is not recommended unless the only alternative would be to discard the sources.

Conclusion

The BoronPlus sources must be cleaned of processing contaminates if optimum results are to be obtained. However, unless the proper cleaning solutions are used, the doping characteristics of the sources may be severely affected. The cleaning procedures outlined in this bulletin will provide the process engineer with the proper techniques for the BoronPlus sources.

For more information on this Product Bulletin or on the BoronPlus and PhosPlus dopant sources, contact the Planar Dopants Team: www.techneglas.com

References:
1. "Hydrogen Peroxide Solutions for Silicon Wafer Cleaning", RCA Engineer, Vol. 28-4, July/Aug 1983, pp.99-105.

2. Hur-Ling Hsiu, "Effect of Solid Source Impurities on Silicon Devices", Thesis at Arizona State University, Dec., 1988.