Performance of the Fourth Generation of Safe Delivery Source® (SDS®4) Package on AIBT iPulsar High Current Implanter

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INTRODUCTION

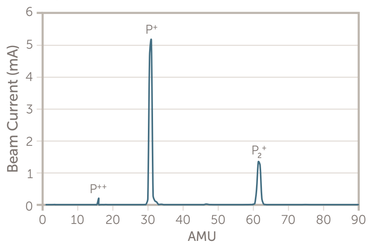
In ion implantation, many of the dopant gases used, such as arsine (AsH_3) and phosphine (PH_3), are highly toxic and it is imperative that the delivery systems for these materials have the highest safety possible. The Safe Delivery Source® (SDS®) family of products have been recognized as the safest gas package for ion implant source gas materials due to its subatmospheric gas storage and delivery. The fourth generation of SDS, named SDS®4, was designed to further improve the safety and gas purity for this application. This poster describes the qualification and performance of SDS4 phosphine (PH_3) and SDS4 arsine (AsH_3) cylinders on an AIBT production tool and compares the results to the current baseline of SDS®3.

TOOL AND EXPERIMENT SETUP

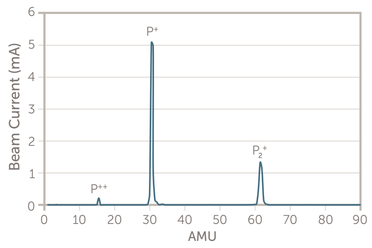
The evaluation was performed on an AIBT iPulsar ion implant tool. The iPulsar is a 300 mm single wafer high-current tool with an indirectly heated cathode (IHC) ion source. SDS4 phosphine (PH_3) and SDS4 arsine (AsH_3) cylinders were installed on the tool along with the same gas types in SDS3 cylinder packaging. SDS3 is the current process of record (POR) for this tool and served as the baseline reference for comparison to SDS4 performance. A 10 keV recipe was tuned for each cylinder in order to collect beam mass spectra, and test wafers were implanted to measure particle counts, sheet resistance (Rs), and secondary-ion mass spectrometry (SIMS) values. Furthermore, another set of wafers for each dopant species was also implanted at a much higher dose level of 1E16 ions/cm² to check the contamination level on the wafer surface.

EXPERIMENT AND TEST RESULTS

SDS3 PH_3
Beam Spectrum – 10 keV

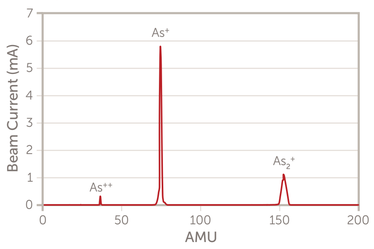


SDS4 PH_3
Beam Spectrum – 10 keV

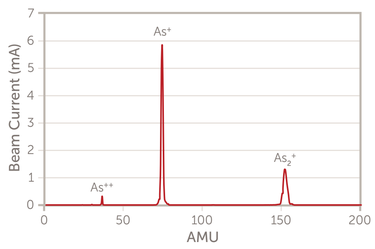


Both SDS3 PH_3 and SDS4 PH_3 cylinders perform similarly and produce typical dopant fragments for P^+ as well as the other two minor peaks for P^{++} double charge and P_2^+ dimer.

SDS3 AsH_3
Beam Spectrum – 10 keV



SDS4 AsH_3
Beam Spectrum – 10 keV



The beam spectra of both SDS3 and SDS4 AsH_3 cylinders show identical beam peaks at As^+ as well as the double charge As^{++} and dimer As_2^+.

Table 1. Particle Test Results

Package	Gas	Energy (keV)	Dose (ions/cm²)	Particle count (>0.034 µm)
SDS3	AsH_3	10 keV	2.00E+15	3
				8
	PH_3	10 keV	2.00E+15	1
				1
SDS4	AsH_3	10 keV	2.00E+15	4
				10
	PH_3	10 keV	2.00E+15	3
				2

The particle counts for all the wafers are at ≤10 added which is within the normal trend seen on this tool and significantly below the specification of the implant tool of below 30 added particle counts.

Table 2. TXRF Contamination Results

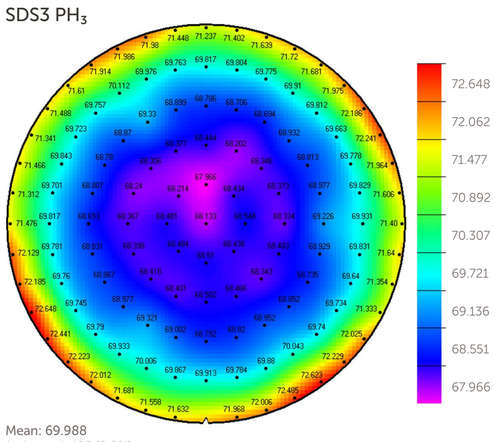
TXRF Measurement	Wafer by SDS3 AsH_3	Wafer by SDS3 PH_3	Wafer by SDS4 AsH_3	Wafer by SDS4 PH_3
K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd, In, Sb, Ba, Ga, Ge, Br, Sr, Y, Zr, Ta, W, Pt, Au, Pb	<1	<1	<1	<1
Na	<10 (DL)	<10 (DL)	<10 (DL)	<10 (DL)
Mg	<10 (DL)	<10 (DL)	<10 (DL)	<10 (DL)
Al	<50 (DL)	<50 (DL)	<50 (DL)	<50 (DL)
Sn	<20 (DL)	<20 (DL)	<20 (DL)	<20 (DL)
Mo	<1.8 (DL)	<1.8 (DL)	<1.8 (DL)	<1.8 (DL)

Unit: x 10^{10} atoms/cm²
DL: Detection limit

TXRF test wafers were implanted at 20 keV and 1E16 dosage. All contaminants are either under the tool specification of $<1 \times 10^{10}$ atoms/cm² or below the TXRF detection limit, which indicates that the SDS4 cylinders were not contributing any additional contaminates when compared to the baseline.

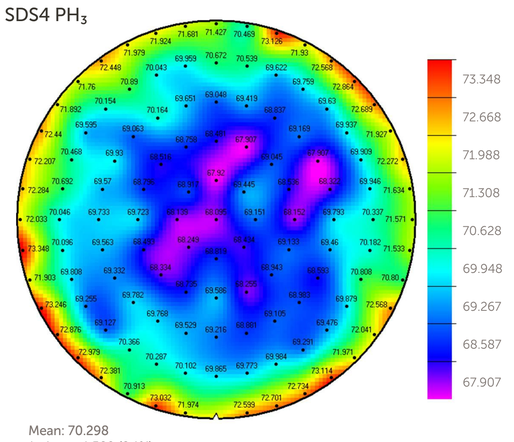
Rs Map

SDS3 PH_3



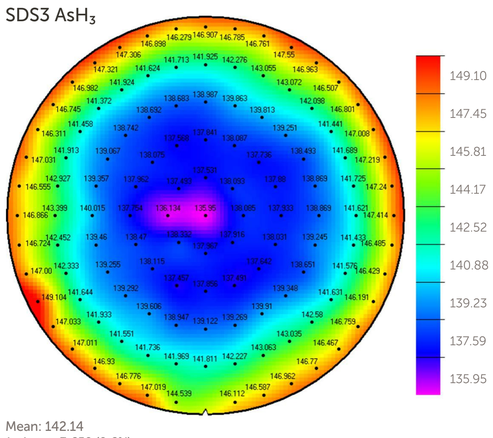
Mean: 69.988
1-sigma: 1.402 (2.0%)
Range: 4.682 (6.7%)

SDS4 PH_3



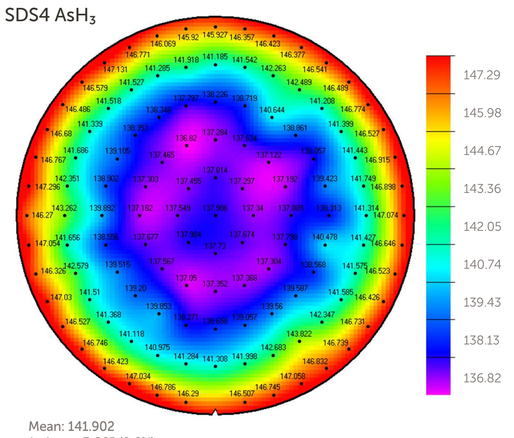
Mean: 70.298
1-sigma: 1.509 (2.1%)
Range: 5.441 (7.7%)

SDS3 AsH_3



Mean: 142.14
1-sigma: 3.652 (2.6%)
Range: 13.154 (9.3%)

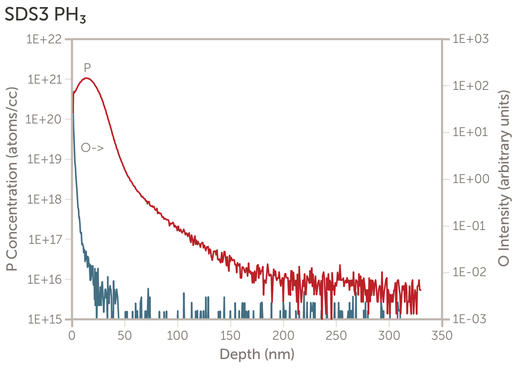
SDS4 AsH_3



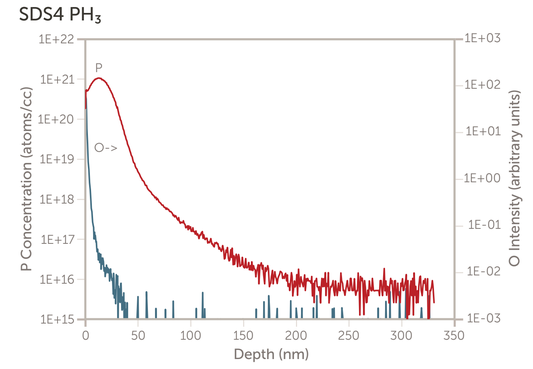
Mean: 141.902
1-sigma: 3.665 (2.6%)
Range: 10.476 (7.4%)

The sheet resistance mean and standard deviation results between SDS3 and SDS4 cylinders are comparable and well within the normal variation from the implant, annealing, and measurement tools.

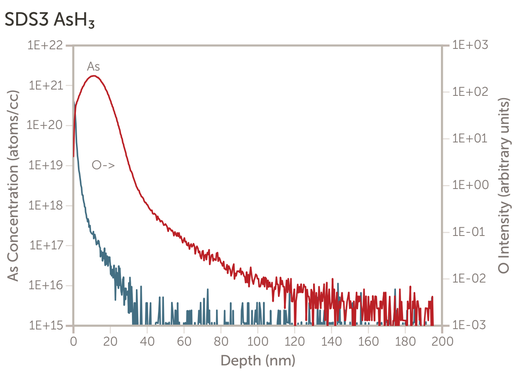
SDS3 PH_3



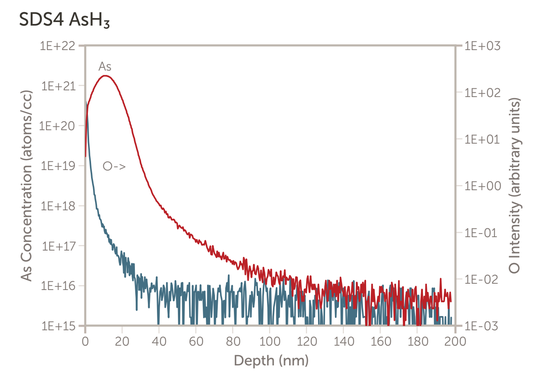
SDS4 PH_3



SDS3 AsH_3



SDS4 AsH_3



The doping profiles for both phosphorus (P) and arsenic (As) are identical between the wafers implanted with SDS3 and SDS4 cylinders. In addition, the accumulated dosage is also matched very well across the different test conditions.

CONCLUSION AND DISCUSSION

The SDS4 cylinder package provides several improved features versus prior generations and this poster reported the results of the qualification of this package on the AIBT iPulsar ion implantation tool. This test showed that the beam spectra, Rs measurement, and particle count results when using SDS4 are comparable to SDS3 cylinders. This has been shown to be the case for both arsine and phosphine and all results are within the tool specification. The SIMS profiles for wafers implanted by SDS4 are comparable to those implanted using SDS3 cylinders. Finally, the wafer surface contamination tests analyzed by TXRF are all within the tool specification or are less than the TXRF detection limit. The data presented in this paper from the evaluation testing indicates that the SDS4 package meets the requirements for the ion implantation process on this production toolset.

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