Next Generation Safe Delivery Source (SDS®4) Dopant Material Storage and Delivery Package

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INTRODUCTION

Sub-atmospheric gas storage and delivery systems, referred to as SAGS Type 1, were developed by Entegris and have been used to deliver gases in ion implant processes for many years under the trade name of SDS®. This technology, reliably adsorbs pure dopant gases on an adsorbent substrate contained within a cylinder package. The SDS platform has been adopted industry wide and has proven to combine inherent gas cylinder safety with adsorption technology in an effective way to allow end users to safely deliver highly toxic materials, thus enabling greater efficiency for ion implant processes.

Adsorbent Screening

In the development of SDS4, the landscape of microporous adsorbents was evaluated and assessed against various criteria, including:

- Density
- Sensitivity to moisture
- Thermal instability
- Volume adsorption capacity
- Volume desorption retention
- Trace metal contamination
- Friability
- Particle generation
- Pressure instability
- Reactivity of adsorbent and adsorbate
- Cylindrical capacity decay
- Manufacturability
- Cost

Entegris has selected and optimized the performance of monolithic microporous adsorbent carbon for SDS4.

Purity

Purification methods and processes have been developed through an extensive series of tests and designed experiments. The continued use of robust and chemically inert carbon adsorbent common to previous SDS products, combined with advanced handling and processing techniques has enabled an extremely high final product purity of SDS4.

Capacity

When working within tight space constraints, such as the gas cabinet on an ion implanter, the optimal adsorbent for gas delivery is a high density microporous material. Having high surface area or gravimetric capacity is not enough if the density is low. Shown at right is the impact of bulk density on the volumetric PH₃ storage capacity.

Safety

A key safety development for SDS4 is a visual valve open/closed indicator. Entegris has worked closely with the valve supplier to develop an application-specific valve state indicator for ion implant cylinders. Cylinders can be installed in either vertical or horizontal orientations in ion implant gas boxes. This indicator allows the user to view if the cylinder is opened or closed from the top or side orientation.

VALIDATION

Several other Metal Organic Framework (MOF) adsorbents display a significant pressure change, indicative of a reaction between the gas and adsorbent. In at least one MOF case the pressure goes super-atmospheric.

Above right displays the resulting color and form change of various MOF materials after going super-atmospheric. Indicators of a reaction and resulting oxidation state change of the MOF transition metal. As can be seen the SDS4 material is stable.

KEY FEATURES

- No significant As+ and P+ beam current change from SDS3 to SDS4 (shown below left)
- No observed source glitching
- VPD-ICPMS analysis for trace elements matched control tool, shown right
- Sheet resistance matched within 1 Ohm control tool
- Particle monitoring has matched within 1.5% of control tool
- SIMS profiles matched within 2% of control tool (shown below right)

Deliverable Phosphine Capacities – 650 to 5 Torr

Trace metals analysis was performed by an independent 3rd party utilizing ICP-MS. In this test SDS4 aspirant was tested alongside a zinc based MOF. The SDS carbon-based adsorbent is the best candidate for this application. Advanced processing techniques enable a high final product purity. Package hardware is designed to further improve the safety, performance, and reliability of SDS4. Final product performance has been verified through external customer testing, confirming SDS4 exceeds ion implant application requirements.

CONCLUSION

An array of microporous adsorbents were identified and screened for use in a SAGS 1 application. Results show that the SDS carbon-based adsorbent is the best candidate for this application. Advanced processing techniques enable a high final product purity. Package hardware is designed to further improve the safety, performance, and reliability of SDS4. Final product performance has been verified through external customer testing, confirming SDS4 exceeds ion implant application requirements.