ZEE® Performance Under Production Conditions

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INTRODUCTION

Test Designed to Validate Field Reports on ZEE® Performance

As a manufacturer of specialty materials, Entegris is in a unique position to use its materials research and development teams, pilot plant production, laboratories for material analysis characterization, and long relationships with OEMs and end users to develop targeted materials for specific applications. The development of a new material targeted for high wear and high energy implant components was based on past performance data for graphites in this application. It was assumed that a graphite material with the right combination of grain size, hardness and uniform microstructure would yield fewer particulates on the wafers and would exhibit reduced erosion in current and next generation processes.

The development process determined that this new graphite grade would need a grain size of 1 micron (smallest that is currently manufactured), a shore hardness above 100, purity levels below 2 ppm and a uniform microstructure. This graphite material developed specifically for high-wear, consumable implant components was trade named ZEE.

When ZEE was released to several beta customers the initial reports from the fabs validated Entegris' premise. Although the field information was semi-qualitative, reports suggested that component life increased from 1.5 to 4 times depending on the part, equipment and process involved. In order to better understand the performance of ZEE, a series of tests were undertaken in a production environment.

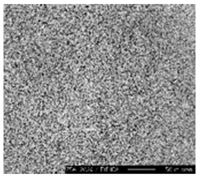
TEST PARAMETERS

Leading Materials Tested Under Production Conditions

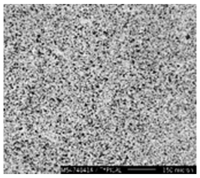
Materials

The MRS vanes from three materials were chosen — Entegris' ZEE and SCF along with a commercially available VI part. The test was designed to compare these three materials under production implant conditions and evaluate the performance differences between these materials. Of particular interest was to explore the combination of microstructure, hardness and particle size that lead to reduced erosion and reduced particulates.

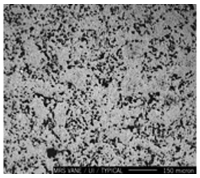
Material differences included grain size from 1–10 microns, the uniformity of material depending on manufacturer and the shore hardness from 79 – 106 (see Figure 1).



Entegris ZEE



Entegris SCF



Competitor VI

Physical property/performance review

Material	Hardness (shore)	Density	Erosion perpendicular to Beam	Weight loss (post U/S clean)	Particulates measured
ZEE-2	100	1.77 g/cm³	63	78	41
SCF-2	95	1.75 g/cm³	90	97	71
VI	79	1.81 g/cm³	100	100	81

Detected during wear testing on MRS vane in AMAT™ 9500 running extended wear As+ implant

Figure 1. Material property comparison

Equipment

AMAT 9500XR located in a CPU fab.

Process

Arsenic implant with dose of 80 keV and energy level of 15 mA. The process simulated extended lifetime conditions. The MRS vanes were run slightly pinched down to simulate extended wear. Results were measured to identify erosion resistance and the amount of particulates added to monitor wafer during the test period. The process was run continuously for 20 hours. The test compared particles coming off the graphite after 20 hours in the chamber onto the wafer. Each test wafer saw one process run.

Particle levels were tested before and after each process. The MSR vanes were weighed before and after the run. The parts were dimensionally measured to capture the erosion of each part.

Component

MSR vane was chosen due to environmental constraints of the system. This part could easily be removed without affecting the rest of the beam line. There were two, identical test components from each material.

Duration

Each process run was 20 hours. Each test wafer saw one process run near the end of the 20 hours.

MEASUREMENTS PERFORMED

Test Measured Particulates Generated and Resistance to Erosion

Measurements taken on each vane were averaged for each test and compared to the other runs. Final data is normalized for comparison purposes.

The data was measured as follows:

Dimensional

Five sites measured along erosion surface.

Weight

Parts weighed after ultrasonic clean at end of run.

Particulates

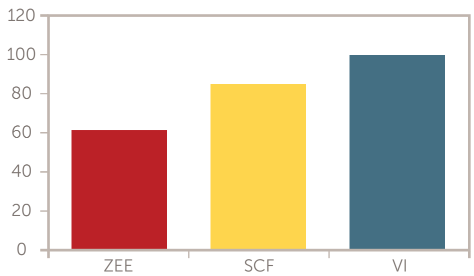
After vanes were installed, a particle check process run was used to verify that the system was running optimally. After the extended run, the particle check process was repeated to simulate particle performance on a wafer based on the erosion of component over its lifetime. The particle monitor wafers were measured using a KLA-Tencor™ 6200 capable of measuring down to 0.16 micron.

RESULTS

ZEE Has Lowest Erosion Rate of Materials Tested

Based on dimensional measurements, components made from Entegris ZEE showed lower wear than either Entegris SCF or VI (see Figure 2).

Erosion



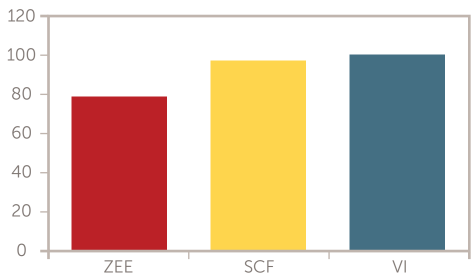
Normalized erosion between ZEE, SCF and VI measured on MRS vanes after accelerated erosion test.

Figure 2. Material comparison results (erosion)

ZEE Generated Fewer Particulates than Competitive Materials

Components manufactured from ZEE showed less weight loss than SCF or VI components (see Figure 3).

Weight Loss

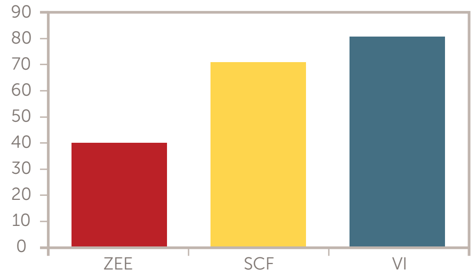


Normalized weight loss between ZEE, SCF and VI measured on MRS vanes after accelerated erosion test.

Figure 3. Material comparison results (weight loss)

Fewer particulates were measured on the monitor wafer from the runs using the ZEE MRS vane (see Figure 4).

Particulates Added



Particulates added during a standard run following the erosion test to simulate particulate performance of a used part.

Figure 4. Material comparison results (particulates added)

CONCLUSIONS

ZEE Outperforms VI

The physical properties that impact erosion resistance are particle size and hardness. While VI and ZEE had the same density, the overall performance was at opposite ends of the scale. The particles generated during the process run using ZEE were half of that generated by the VI components. The erosion resistance of ZEE was 40% less than VI.

The performance results between SCF with a 5 micron particle size and VI with a 10 micron grain size was somewhat similar. Only ZEE exhibited significant performance differences from the other two materials.

It is possible that performance is an interaction of several physical property variables. The data shows that significant performance can be achieved from a combination of physical properties that include 1 micron grain size, shore hardness above 100 with a uniform microstructure.

This test did not address improved yield results, but it is interesting to note that the fab that ran the test has switched all graphite materials from OEM standard materials to Entegris ZEE and has experienced a reduced cost per wafer in the fab.

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