

# High Density, Plasma Flood System (HD PFS) Yield Enhancement for the Precision Implant 9500

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**Abstract** - Thinner gate insulators and larger effective antenna ratios require continuous improvement of charging control for leading edge devices. A beta version of the HD PFS demonstrated a yield advantage over the original 9500 PFS with new products. Split lots were run for high current implant of 0.50 micron EEPROM devices with a 10 nm gate oxide insulator. Initial beta service life was one month. Expected filament life is significantly longer.

## I. INTRODUCTION

Wafer charging control requires continuous improvement, because smaller critical dimensions have lower voltage gate insulators and larger effective antenna ratios. Thus, newer generation devices are even more sensitive to charging damage, pushing charging control requirements to lower voltages. Simultaneously, cost of ownership economics demands that process tools have higher reliability, higher availability, and longer preventive maintenance intervals. The High Density Plasma Flood System (HD PFS) represents a significant hardware upgrade of the plasma flood technology originally developed for the Precision Implant 9200 [1]. The flood combines a patented magnetic-filter plasma arc source and guide tube with Applied Materials' patented accel/decel flood technology. It has demonstrated leading edge charging control on standard test wafers [2]. This paper reports on initial product yield and reliability using a beta version of the HD PFS on a Precision Implant 9500 in a commercial fab.

## II. PRODUCT YIELD ENHANCEMENT

Yield enhancement was gauged by comparing the results of charging sensitive implants for split lots with two 0.5 micron products with 10 nm gate oxides. Higher yield was found for plug and P+ implants on 4 MB FLASH memory, and for plug and N+ implants on 8 MB FLASH memory. The results are plotted in Fig. 1 as projected yield changes (delta) compared with the yield expected from a standard 9500 PFS. These yield results were obtained in the first weeks of beta operations. For the plug implants, the HD PFS was operated at 1 Amp arc. For the N+ and P+ implants, the HD PFS arc was at 0.7 Amp arc. The enhanced yield is based on comparison with normal yield using the standard 9500 PFS operating at 30 V, 6 Amp arc for the plug implants and 4 Amp arc for the N+ and P+ implants.

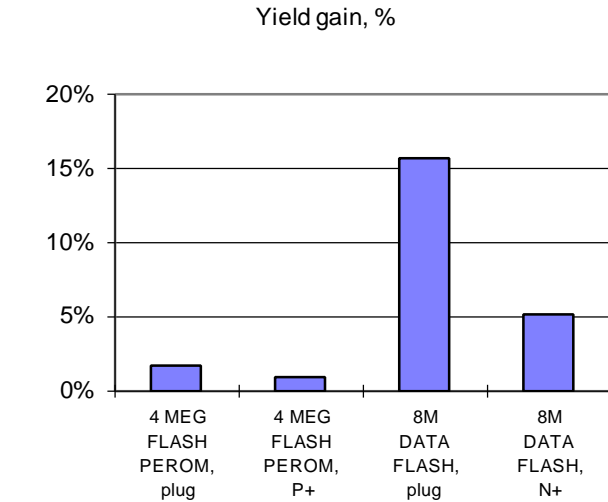


Fig 1. HD PFS split lot yield enhancement for FLASH memory implants, based on comparison with a standard PFS on a Precision Implant 9500.

For all cases, arc voltage was 30 V, with -10 V tube bias and 1.6 sccm Ar flow. Statistically significant yield enhancement was found for the HD PFS with the 8 MB FLASH plug implant and N+ implants. Further device testing showed improved time to breakdown of the gate dielectric, approximately 3-4 seconds longer.

## III. STABILITY

Flood stability is illustrated in Fig. 2, where emission current is plotted for various product recipes during twenty-two days of production. The initial drop in emission current during the first day of operation is believed to be due to an insulating layer of photoresist on the surface of the guide tube. At present, it is impossible to say whether this indicated change in emission is real, or, significant in the sense that the flood should be adjusted. However, it certainly indicates the need for the flood to demonstrate a wide operating window with high test structure yield during development testing with a clean beamline. After the first two days, the indicated emission current stabilized within a 10 mA range for most processes. With this beta source, some of the variation in emission current was due changes in end station pressure due to target outgassing during implant. The production release HD PFS will have reduced aperture area that will marginally reduce emission, but significantly reduce gas flow and sensitivity to end station pressure.

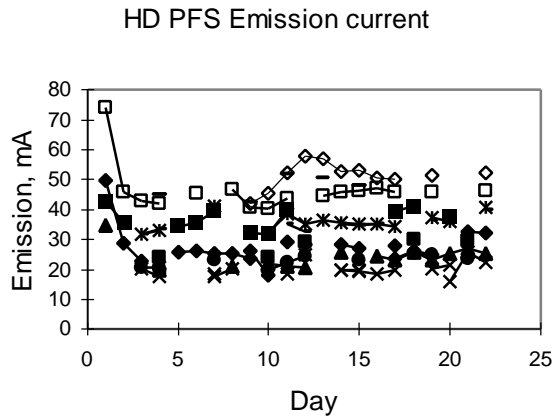


Fig 2. HD PFS emission current stability for various production processes during a 22 day production run on a Precision Implant 9500.

Primary flood HD PFS control parameters are arc voltage, arc current and tube bias potential, because these are unambiguously measurable. It is tempting to regulate on emission current, or, wheel current, because these more directly relate to charging control. However, emission current and tube current represent the net of unknown ion and electron currents. These net currents are clearly sensitive to surface and vacuum conditions, but a detailed relationship to actual flood plasma conditions and charging control has not been established. Therefore, emission current and wheel current are regarded as secondary parameters, qualitatively useful but ambiguous.

Similar ambiguity exists today for all plasma floods systems. This complicates detailed comparison of different types of charging control systems based on these secondary parameters. Nevertheless, emission and/or wheel currents do provide accessible qualitative indicators flood performance. They also provide a convenient basis for monitoring a particular flood system over time.

#### IV. SERVICE LIFE

One month service life was demonstrated during the initial operation of the beta source in production. At that time, the arc became unstable, and the filament insulators were found to be cracked. This weakness has been corrected in production versions. The filament itself looked new, a result of high emission efficiency compared with the standard PFS. This indicates that filament life is unlikely to limit service life and that ample reserve emission capacity is available to meet future requirements.

#### REFERENCES

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2. H. Ito, H. Asechi, Y. Matsunaga, M. Niqayama, K. Yoneda, M. Reilly, and W. Hacker, High Density Plasma Flood System For Wafer Charge Neutralization, IIT Conference, Japan, June 1998.