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High Voltage Ionization during Plasma Immersion Ion Implantation

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During the plasma immersion ion implantation (PIII) process, ions are typically created by an external plasma source, such as electron impact glow discharge using hot filaments, radio frequency, electron cyclotron resonance, metal arc, and so on. There is, however, a less obvious ion formation mechanism by the high voltage itself, especially for a long pulse duration or at high working pressure, as shown by the implantation current not decreasing monotonically as predicted by the Child-Langmuir law. A proof of this secondary phenomenon is that the measured total current sometimes increases dramatically in a low vacuum sustained by RF glow discharge. Another example is that the current can gradually rise after a short delay during long pulse, hot filament glow discharge PIII. These phenomena can be attributed to high voltage ionization during the PIII process and are related to the gas pressure, high voltage pulse duration, target size, target materials, and so on. In this paper, we will present supporting experimental data in addition to a theoretical analysis.

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Influence of Sample Placement on Dose Uniformity in Plasma Immersion Ion Implantation of Industrial Bearings

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Plasma immersion ion implantation (PIII) is an effective technique to enhance the surface properties of industrial components possessing an irregular shape such as ball bearings. However, it is difficult to achieve uniform implantation along the groove surface on such a bearing and our previous work indicates that the angle of incidence is the primary factor affecting the lateral uniformity. As the incident angle is more glancing toward the edge of the bearing, it is possible to change the sample placement to attain better dose uniformity. In this work, three practical sample stage configurations are investigated: (a) direct placement on the sample stage platen, (b) placement on a copper shroud extension with the same diameter as the bearing resting on the sample platen, and (c) placement on a copper plate connected vertically to the sample platen by a small copper rod for electrical contact. Using a theoretical model developed from our previous work, the largest dose is achieved along the race surface for (c) whereas the best uniformity is observed for (b). Our simulation results also reveal that in (a), the highest dose is observed in the lower part of the groove (closer to sample platen) and it is verified experimentally. Hence, in order to improve the lateral dose uniformity across the groove surface, the ball bearing must be elevated from the sample platen using an extension. The diameter of the extension relative to the bearing also affects the total dose and uniformity. The right combination depends on the tolerable non-uniformity as well as the capacity of the pulsing power supply as a larger extension rod will increase the current demand.