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TWO DIMENSIONAL PARTICLE-IN-CELL SIMULATION OF PLASMA IMMERSION ION IMPLANTATION INTO RING SHAPE TARGET

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Abstract

Plasma Immersion ion implantation (PIII) is a burgeoning non line-of-sight technique for the surface modification of industrial components [1-3]. One of the advantages over ion beam implantation techniques is its ability to rapidly treat objects possessing an irregular shape [4]. Moreover, as there are almost no dimensional changes after implantation, the technique is a very effective way to enhance the surface properties of mechanical parts having strict dimensional tolerances such as precision bearings [5]. The viability of the PIII technique in an industrial environment hinges on the uniformity of the implantation dose along the working surface. For ring shape target, uniform implantation along the inner and outer surfaces is complicated. In this work, we conduct a systematic investigation on the implantation dose uniformity on both the inner and outer surfaces of a number of ring shape target, including a short thin tube, a thick ring, and a ball bearing, using a particle-in-cell simulation. The work is aimed at better understanding of the treatment process for industrial components as well as the plasma sheath evolution in the vicinity of a ring shape target. It has been shown that by inserting a zero potential conductive auxiliary electrode along the axis of the implanted cylindrical tube, the internal electric field will increased and the average ion impact energy can be raised [6]. We will compare the difference of implantation doses with and without the auxiliary electrode. The ring shape target is an open geometry that is open to the plasma at both ends. We will show that providing the longitudinal electric force is strong enough, in the case of a short thin tube, the ions will cross the mid-plane of the tube and stab through the sheath into the bulk plasma. We observe that once the electric field is fully established at longer time, the ions crossing the sheath are either pull away from the open mouth of the ring or push through the ring. Therefore, at longer time the inner surfaces of the ring shape target will not be implanted. We can conclude that the inner surfaces of any ring shape target can not be implanted by direct couple method, that is, applied a steady potential to the target. The only way to implant the ring shape target is to apply a series of negative potential pulses to the target.

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