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Plasma Immersion Ion Implantation of Insulating Materials

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Plasma immersion ion implantation emulates conventional ion-beam implantation in large-area processing and the treatment of objects with an irregular shape while obviating the need for complex manipulation of the target holder. Plasma immersion ion implantation (PIII) was proposed in the mid 1980s and has mostly been applied to the conducting materials or semiconductor materials. There has been interest in extending the technology to the treatment of insulating materials such as polymers, ceramics, rubber, etc. Implantation into components involving insulating materials is sometimes necessary to boost the properties and performance. In this paper we describe the research work related to the plasma implantation of insulating materials. In recent years, we have conducted numerical simulation using plasma fluid model and particle-in-cell (PIC) model as well as experimental investigation. During implantation of insulating materials, capacitance effects and surface charging reduce the energy of the incident ions. Severe charging happens at the initial time stage and the insulating sample on the metal target holder introduces distortion in the plasma sheath leading to complicated implantation dynamics. Interestingly, the incident ion dose sometimes depends on the width of insulating sample. In order to improve the implantation energy, a metal grid is used to accelerate the ions from the plasma and our results show that it is an effective technique for thick or large objects. The metal grid not only improves the implantation energy and the incident dose but also reduces the possibility of surface arcing. The shadowing effect induced by the grid is also discussed.