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6P09

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Particle-in-cell modeling of electron oscillation inside a vacuum arc plasma source duct

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Vacuum arc or cathodic arc metal plasma sources can deposit high quality thin metal films and metallurgical coatings. A metal plasma consisting of positive metal ions and electrons is created when an arc discharge is triggered between two metal electrodes in vacuum. Metal plasma immersion ion implantation can improve the wear and corrosion resistance of the treated surface. A three-dimensional particle-in-cell (PIC) numerical model has been developed to simulate the motion of electrons inside the duct of a vacuum arc metal plasma source. It is found that electrons will travel back and forth inside the duct tube. This new phenomenon can be explained by the combined effects of the electric and magnetic fields. The electron oscillation will increase the charged state of the positive ions and the ions will consequently gain more energy. Due to the influence of electron oscillation, the plasma throughput of the duct will be different from that of a duct under the influence of only the magnetic field. This novel finding should be taken into account when designing metal arc sources and optimizing their performance.

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Generation of High Charge State Ions in Vacuum Arc Ion Sources by a "Current Jump" Method

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GENERATION OF HIGH CHARGE STATE IONS IN VACUUM ARC ION SOURCES BY A "CURRENT JUMP" METHOD

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In our investigation of ion charge state distributions (CSD) in vacuum arc plasmas, good correlation between increase in arc operating voltage and mean ion charge state has been established [1]. Therefore, to increase the mean charge state of a vacuum arc plasma, it is necessary to find ways to increase the arc operating voltage. The voltage can be increased via transients associated with the arc current by means of which a rather high operation voltage can be established across the discharge gap.

Experiments were performed both in Tomsk and Berkeley with the discharge system of a vacuum arc ion source. To effect a step current rise an additional power supply was connected to the usual vacuum arc supply. This power supply made it possible to increase the vacuum arc current up to 1 kA for several μs. As a rule the current jump was produced after 100 – 200 μs into the main discharge pulse when all principal parameters of the vacuum arc were already established. To measure the CSD a time-of-flight method was used.

As followed from experiments, superposition of a short, high current pulse to the vacuum arc current pulse is accompanied by a jump in arc operation voltage. Subsequently during the current step the voltage falls exponentially to one hundred volts after the completion of the current jump, and the arc voltage takes its conventional value (20-40V). Because of this increase in arc operation voltage, an enhancement of high charge state ion fraction was observed. For example, with a Ti-cathode with conventional arc parameters there is only very small value of Ti^{4+} ion fraction in the vacuum arc plasma. Applying strong magnetic field increases the fraction of these ions up to 20% of the total beam current. The current jump enhanced this value up to 40%.

1. E.M. Oks, A. Anders, I.G. Brown, M.R. Dickinson, R.A. MacGill, IEEE Trans. Plasma Sci. **24**, 1174 (1996).