論　文

Ti陰極N2ガス導入真空アークプラズマの質量スペクトルおよびイオンエネルギー分布計測

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Mass Spectroscopy and Ion Energy Distribution Measurement in Vacuum Arc Plasma with Ti Cathode and N2 Gas Flow

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Mass spectra and ion energy distribution in a conventional reactive vacuum arc deposition apparatus with Ti chathode and N_2 gas flow were measured. The experiment was carried out at different distances from the cathode surface as a function of gas pressure with an energy quadrupole probe analyzer. From the result of mass spectroscopy, it was found that Ti and N_2 existed in the plasma as neutral particles, and that N might exist as well.

From the data of ion energy measurement, very few N_3^+ and TiN^+ were also identified as well as Ti^+, Ti^{++}, N^+, and N_2^+. It was found that their energies and relative quantities depended on the distance from the cathode surface and the gas pressure. Ti^{++} had the highest energy as high as 130 eV and the widest distribution among the ions concerned, and its energy distribution had two peaks at lower pressure and at the position near the cathode. The energy of Ti^{++} decreased with the distance from the cathode surface and increasing the gas pressure. The amount of Ti^+ increased with distance and the energy was relatively low. The profile of the energy distributions of N^+ and TiN^+ showed a similarity to that of Ti^{++}. The peak energy of N_2^+ also had lower energy of about 10 eV, compared with Ti^{++}, N^+ and TiN^+.

Taking into account the potential hump theory of the cathodic arc, we proposed a novel reaction process in the plasma based on the results obtained here.

キーワード：反応性真空アークプラズマ，EQP装置，質量スペクトル，イオンエネルギー分布，反応プロセスモデル

1．はじめに

窒化チタン（TiN）膜は，高融点，高硬度で優れた熱伝導性をもっているため，近年，切削治具などへの耐摩耗性被膜として実用化されてきている(1)。TiN膜の生成法として，最近では，真空アーク蒸着法が利用されるようになってきた。同手法は以下のような数々の利点を有している(2)。まず，金属蒸発物のための容器を必要とせず，蒸発物質を高純度に保てる。また，蒸発源を自在にかつ一度に複数個配置できるため，装置の大型化が容易であり，複雑な形状をした物体へのコーティングが可能である。更に，蒸発量が多く，金属蒸気のイオン化率やイオンエネルギーが高いため，成膜速度が速く，基板との密着性がよく，低温基板へも成膜ができる。しかしながら，真空アーク蒸着技術は，未だ不明な点が多く残されている。蒸着に有効な圧力範囲における真空アーク自体のプラズマ状態(3)~(5)が徐々に解明されつつあるものの，十分とは言えない。

著者らの一部は，これまで，TiN膜生成用のTi陰極N_2ガス導入真空アークに関し，プラズマからの放射を分光診断し，プラズマ中にN_2，N_2^+，Ti，Ti^+，Ti^{++}の粒子が存在することを明らかにした(6)。また，ファラデーカップを用い，プラズマ中のイオンエネルギーを計測してきた(7)。しかしな