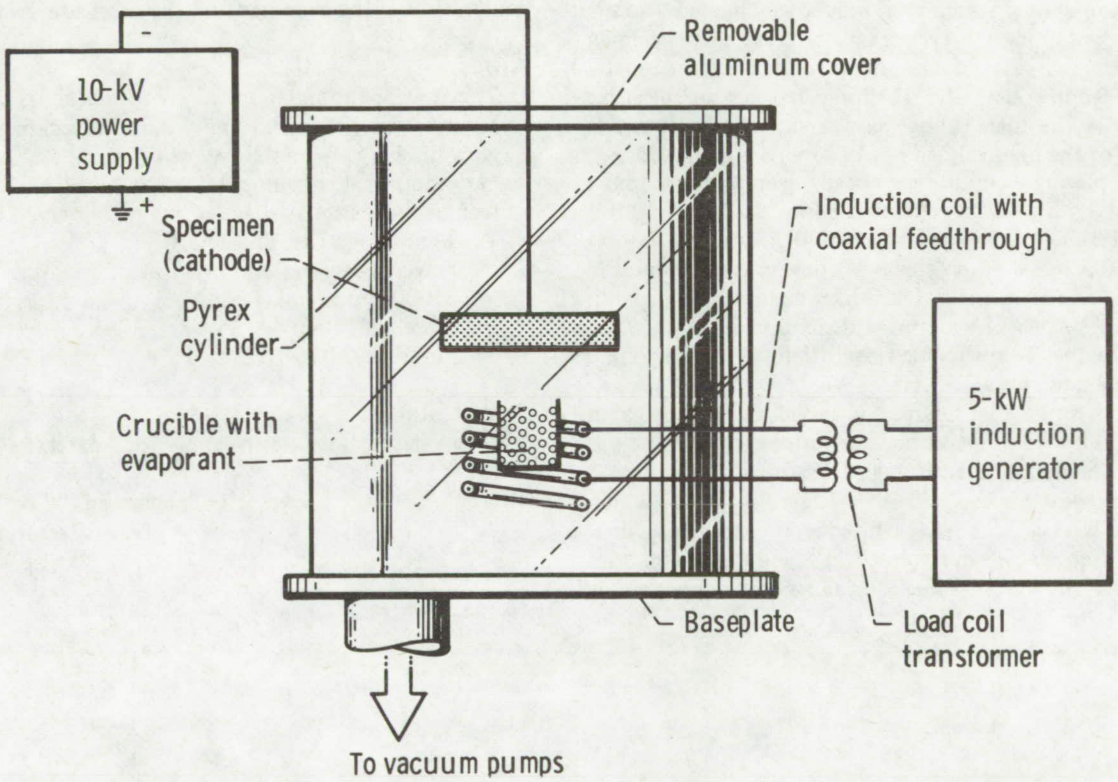
NASA TECH BRIEF

Lewis Research Center

Induction Heating Simplifies Metal Evaporation for Ion Plating



Ion plating with induction heating source.

The Problem:

Because of its simplicity and convenience, the vapor source most commonly used in ion plating is resistance heating, utilizing a refractory metal boat or filament. However, resistance heating cannot be used for evaporating metals which at high temperatures in their molten state react with the boat or for evaporating metals with very high melting points. To vaporize such materials, other evaporation methods have been tried, some successfully. For example, electron beam evaporation has filled many of the needs which could not be performed by resistance heating. The main reason why electron beam evaporation is not utilized on a larger commercial scale in ion plating is because the operations are highly complicated. Other methods which have been tried on a limited scale are arc discharges and sputtering targets. Each of these techniques has its advantages and disadvantages which essentially depend on the particular application.

(continued overleaf)

The Solution:

The use of induction heating as the evaporation source under glow discharge conditions offers a simplified approach. By utilizing a bare induction coil without any shielding, the evaporant source can be heated directly in the glow discharge region with no arcing.

Metals which cannot be evaporated by resistance heating can easily and quickly be evaporated by induction heating. The unique characteristics of ion plating are retained in terms of throwing power and penetration or alloying affects which are responsible for strong adherence.

How It's Done:

A schematic diagram of ion plating by induction heating is shown in the figure. The apparatus consists essentially of the specimen (cathode) to be coated and the evaporation source which is an inductively heated ceramic crucible containing the evaporant material. The specimen is an integral part of the high voltage ceramic-metal vacuum feedthrough and is connected to the negative terminal of the high voltage power supply. The positive terminal of the high voltage power supply is grounded.

The plating conditions used were those most commonly utilized in industrial ion plating; negative potential 3-5 kv, argon pressure 15-20 μ, and the current density 0.3 to 0.8 ma/cm^2. A conventional induction generator of a frequency of 450 KHz cannot be utilized in ion plating since severe arcing of the coil takes place in the glow discharge. To overcome this difficulty, the frequency was reduced to about 75 KHz.

As shown in the figure, an induction generator in conjunction with a load-coil transformer supplies power through the coaxial feedthrough to a four-turn induction coil (voltage across coil is 70 volts RF) which accommodates a 2.5 cm (1 in) diameter ceramic crucible. At these frequencies and voltages, the induction coil does not require any external shielding and a bare copper coil is used.

A number of metals which were practically impossible to deposit by resistance heating evaporation due to severe alloying with the refractory boat can now effectively be evaporated and deposited by induction heating in any desired thickness. Metals, particularly metals such as nickel and iron, have been deposited up to thickness of 50 μm (2 mils), with the strong adherences normally obtained in ion plating. High temperature melting materials such as refractories can also be evaporated by induction heating, utilizing the appropriate capacity induction generator.

Evaporation by induction heating in ion plating has an additional feature which resistance and electron beam methods do not possess. It produces a significant degree of ionization of the evaporant metal. The additional amount of the ionized metal evaporant is of great importance in ion plating since this enhances the degree of penetration of the evaporant on the substrate.

Notes:

1. The low operating frequency of 75 KHz is the basic requirement for operating a bare induction coil in a glow discharge region.
2. No additional documentation is available. Specific technical questions, however, may be directed to:

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   Lewis Research Center
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   Reference: B75-10288

Patent Status:

NASA has decided not to apply for a patent.

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