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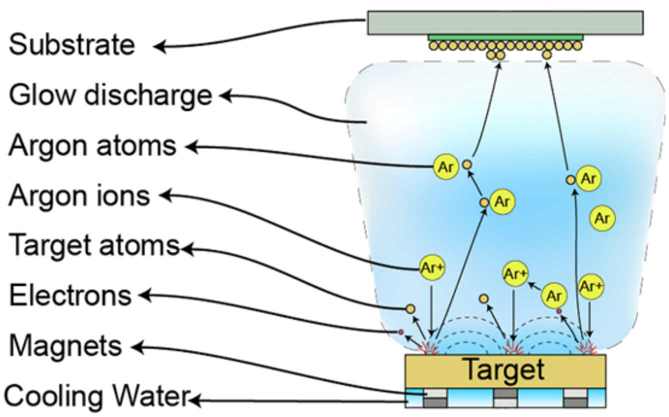
Magnetron Sputtering Technology

Basic Sputtering Process

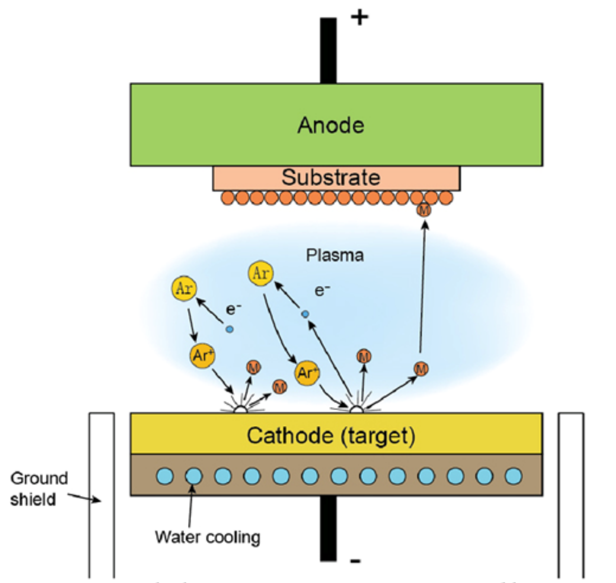
There are many different ways to deposit materials such as metals, ceramics, and plastics onto a surface (substrate) and to form a thin film. Among these is a process called "SPUTTERING" that has become one of the most common ways to fabricate thin films. Sputtering is a physical vapor deposition (PVD) process used for depositing materials onto a substrate, by ejecting atoms from such materials and condensing the ejected atoms onto a substrate in a high vacuum environment.



The basic components of a magnetron sputtering system. Ionized Argon bombards a target, releasing atoms which form layers on a substrate. Electrons and Argon ions form a plasma, which is located near the target due to the magnetic field, resulting in greater efficiency and quality.

The basic process is as follows. A target, or source of the material desired to be deposited, is bombarded with energetic ions, typically inert gas ions such as Argon (Ar^+). The forceful collision of these ions onto the target ejects target atoms into the space. These ejected atoms then travel some distance until they reach the substrate and start to condense into a film. As more and more atoms coalesce on the substrate, they begin to bind to each other at the molecular level, forming a tightly bound atomic layer. One or more layers of such atoms can be created at will depending on the sputtering time, allowing for production of precise layered thin-film structures.

Though the basic idea of operation is seemingly simple, the actual mechanisms at play are quite complex. Electrically neutral Argon atoms are introduced into a vacuum chamber at a pressure of 1 to 10 mTorr. A DC voltage is placed between the target and substrate which ionizes Argon atoms and creates a plasma, hot gas-like phase consisting of ions and electrons, in the chamber. This plasma is also known as a glow discharge due to the light emitted. These Argon ions are now charged and are accelerated to the anode target. Their collision with the target ejects target atoms, which travel to the substrate and eventually settle. Electrons released during Argon ionization are accelerated to the anode substrate, subsequently colliding with additional Argon atoms, creating more ions and free electrons in the process, continuing the cycle.



In a DC diode sputtering system, Argon is ionized by a strong potential difference, and these ions are accelerated to a target. After impact, target atoms are released and travel to the substrate, where they form layers of atoms in the thin-film

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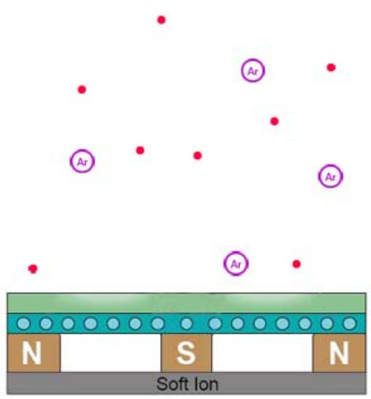
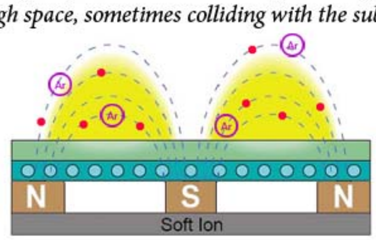
Magnetron Sputtering Process

There are a number of ways to enhance this process. One common way to do this is to use what is known as a magnetron sputtering system. The main difference between this and a basic DC sputtering system described above is the addition of a strong magnetic field near the target area. This field causes traveling electrons to spiral along magnetic flux lines near the target instead of being attracted toward the substrate. The advantage of this is that the plasma is confined to an area near the target, without causing damages to the thin film being formed. Also, electrons travel for a longer distance, increasing the probability of further ionizing Argon atoms. This tends to generate a stable plasma with high density of ions. More ions mean more ejected atoms from the target, therefore, increasing the efficiency of the sputtering process. The faster ejection rate, and hence deposition rate, minimizes impurities to form in the thin-film, and the increased distance between the plasma and substrate minimizes damage caused by stray electrons and Argon ions.



In a non-magnetron sputtering system, the plasma is not confined, and electrons and Argon ions propagate through space, sometimes colliding with the substrate.



In a magnetron sputtering system, the plasma is confined to an area where the magnetic field is strong. The nearness of the plasma to the target causes faster deposition rates, greater Argon ion replenishment, and less substrate damage from stray particles.

A way to measure target deposition rate is something called the "SPUTTERING YIELD". The sputtering yield is defined as the number of target atoms released per incident Argon ion with certain kinetic energy. For example, if two target atoms are released per collision with an Argon ion, the sputtering yield is two.

To sputter conducting targets, a DC power supply is generally used. For insulating or semiconducting targets, an RF power supply is required with an automatic or manual impedance matching network between the power supply and the sputtering gun. Micro Magnetics recommends an automatic network for an RF power supply. Micro Magnetics' magnetron sputtering guns are designed to work with any DC and RF power supplies for sputtering applications. We do recommend customers use the DC and RF power supplies marketed on our online store www.directvacuum.com. They offer excellent functionality, ease of use, stability, and compatibility.

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Micro Magnetics' Magnetron Advantages

One shortcoming of magnetron sputtering techniques is the limited capability for using magnetic target materials. In many magnetron sputtering systems, the magnetic nature of the target material interferes with the magnetic field generated by the sputtering gun, severely reducing the efficiency of the magnetron system. However, Micro Magnetics' magnetron sputtering gun design solves this problem, allowing a wide range of target materials, including magnetic materials, to be used. Other manufacturers generally market two types of sputtering guns, one for non-magnetic targets and the other for magnetic targets, with the latter costing significantly higher. Micro Mangetics' sputtering guns are designed for both non-magnetic and magnetic targets with one low list price.

Although our magnetron sputtering systems utilize concepts similar to other systems, there are a few key differences which make Micro Magnetics systems the superior solution for your thin-film deposition needs.

First, we use state-of-the-art Finite-Element-Analysis software based on novel physics research done by Micro Magnetics to create the magnetic circuitry in our magnetron guns. We spend countless hours in the lab to make sure we are utilizing the most innovative concepts possible to optimize the quality of our sputtering systems.

Second, we use high-quality NdFeB permanent rare-earth magnets to create very strong fields, which increase deposition efficiency and thin film quality. Also, magnets used in Micro Magnetics' sputtering guns have a high Curie temperature, ensuring their integrity even at high operating temperatures. Some vendors use lower quality magnets to cut costs, which can lead to irreversible magnet degradation and increased total costs in the future.

Finally, MicroMagnetics only uses the highest quality ceramics and metals as well as cutting-edge fabrication methods to produce the best and most easy-to-use sputtering guns on the market. We do not skimp on quality and durability to save costs, and that is why Micro Magnetics' sputtering guns offer significant competitive advantages.