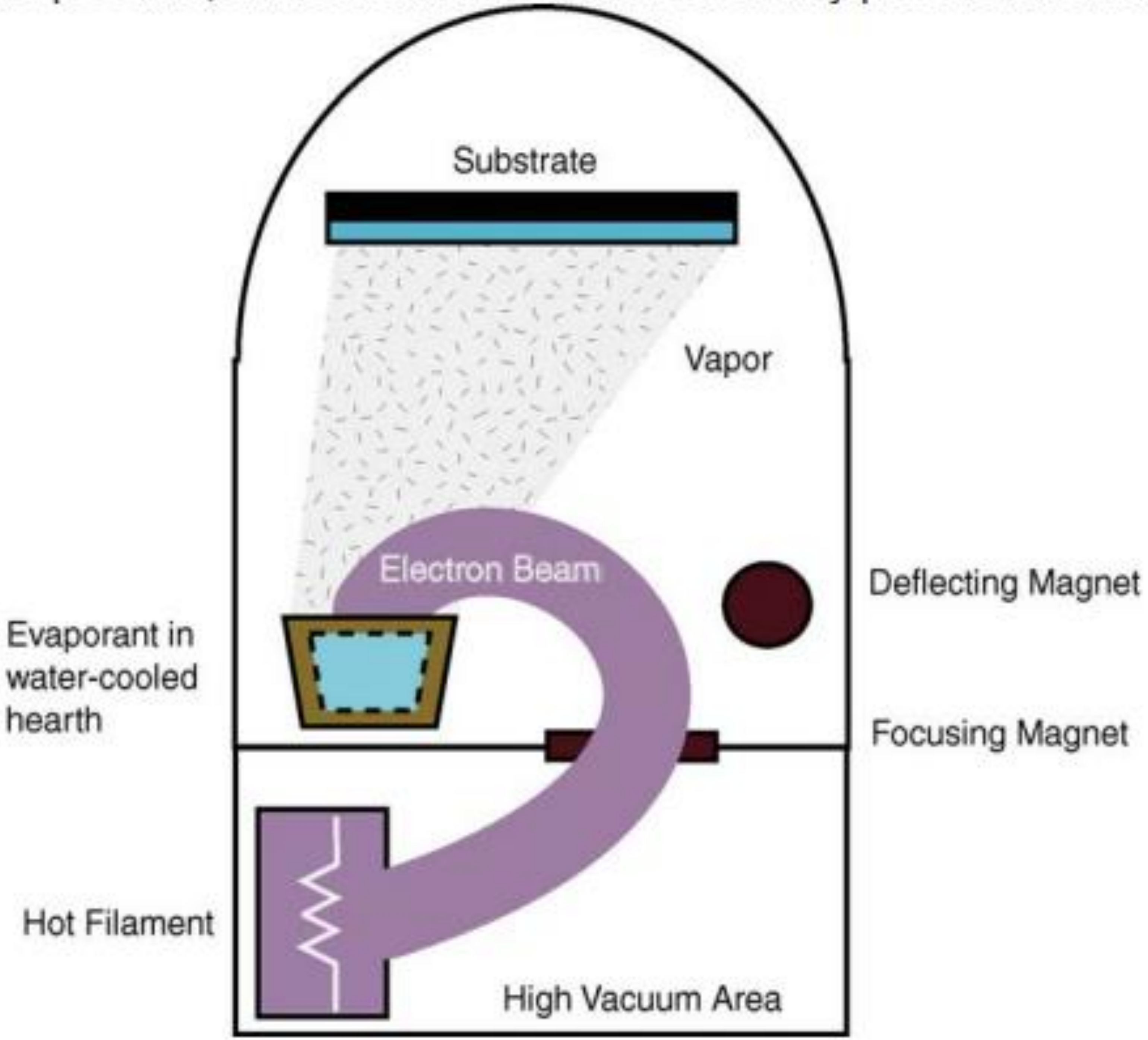
Electron Beam Evapuration

The Electron beam evaporation is process of depositing the thin films.

The electron beam method of evaporation is of interest to both decorative and functional metallizers. A wide variety of materials including refractory metals (such as tungsten), low vapor pressure metals (such as platinum), and alloys can be evaporated. Since the electron beam method concentrates large amounts of heat on a very small area, high rates of deposition are possible, a factor which is of interest to any production-oriented shop.

Figure


Substrate
Vapor
Electron Beam
Deflecting Magnet
Evaporant in
water-cooled
hearth
Focusing Magnet
Hot Filament
High Vacuum Area

Steps Involved in Electron Beam Evapuration

1 Filament is heated until it emits electrons. 2. Electrons leave the gun. 3. The beam is focused and bent by the magnet. 4. The beam plays upon the surface of the evaporant causing heat and vaporization. 5. The vapor condenses on the substrate surface.

Working

The process begins under a vacuum of 10^{-5} torr or less. A tungsten filament inside the electron beam gun is heated. The gun assembly is loacated outside the evaporation zone to avoid becoming contaminated by evaporant. When the filament becomes hot enough, it begins to emit electrons. These electrons form a beam which is deflected and accelerated

Working

toward and focused on the material to be evaporated by means of a magnetic or electric fields. When the electron beam strikes the target surface, the kinetic energy of motion is transformed by the impact into thermal energy (heat). It is important to remember that the energy given off by a single electron is quite small and that the heating is accomplished simply by virtue of the vast number of electrons hitting the evaporant surface. This is the energy which vaporizes the target material. The energy level achieved in this manner is quite high - often more than several million watts per square inch. Compare this to the heat given off by a 100 watt light bulb and you can begin to appreciate the magnitude of heat generated. Due to the intensity of the heat generated by the electron beam, the evaporant holder must be water cooled to prevent it from melting.

Working

The power supply for this operation is a high voltage D.C. power supply. The voltage is typically 10 to 30 kilovolts, with a wattage ranging anywhere from 10 to 30 kilowatts.

The deflection/focusing apparatus is designed using either permanent magnets or electro-magnets to create a field which can shape and direct the path of the electrons. This is necessary because the electrons are emitted in a random manner and must all be directed to the very small area where the evaporation will occur. A magnetic field is used since it can directly attract or repel the negatively charged electrons. Lenses or other mechanical focusing devices would be ineffective, and subject to the heating process themselves.

Working

Alloys may be evaporated directly from an alloyed evaporant, or they may be constructed during evaporation by simultaneously evaporating two or more materials. This process can even produce composite films of materials which could not normally be made into an alloy because they have vastly differing melting points or because on of the components sublimes (goes directly from a solid to a vapor with no liquid phase) and therefore could not be alloyed in the traditional manner. Also, alloys with components having very different vapor pressures should be evaporated this way since traditional heating methods would tend to cause the components to separate during evaporation (due to the distillation effect).

Disadvantages/Liabilities

The electron beam process has several liabilities which must also be considered. Capital equipment expenditures are higher than those required for evaporation using filaments. High currents are necessary for operation. E-beam activities generate X-rays. In general, the equipment is more complicated than that in a filament evaporation unit and operators must be more highly skilled.