

Crystal Film Thickness Monitors

Published now and again

by MIDWEST TUNGSTEN SERVICE

For decorative metallizing operations, exact measurement of the deposited film thickness is not usually required. Decorative metallizers are primarily concerned with the appearance of a coating. Two primary decorative characteristics controlled by film thickness are opacity and reflectivity. For a decorative coating, the metallizer can often rely on a trained eye to make judgments regarding proper film thickness. For more on this subject, see our TIPS [How Thick Is The Film?](#)

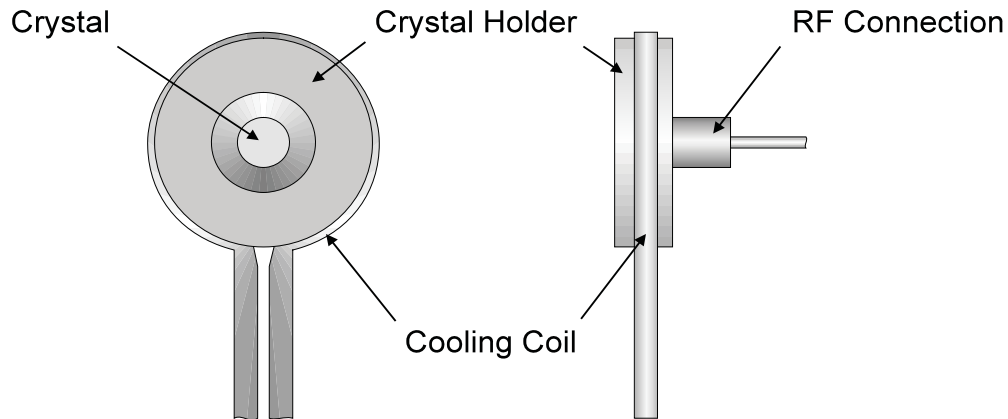
For other thin film coaters, gross measurements simply are not good enough. In applications where electrical or optical properties are important, precise measurements of not only film thickness, but also the deposition rate are important. Thickness of films can alter properties such as resistivity, capacitance, durability, optical wavelength, reflectivity, and opacity. The rate at which a film is deposited can alter its crystal structure, amount of included gas, adhesion, stress, resistivity, and optical properties. Other properties may be affected as well. Therefore, monitoring and controlling these variables can be critical in obtaining the properties desired for a particular film.

Older techniques for measuring film thickness rely on using a micrometer, a mechanical stylus, or a multibeam interferometer to measure thickness after the part is removed from the chamber. Another approach is to weigh parts before and after deposition and use the total coated surface area as a factor to mathematically determine film thickness. By knowing the time it takes to make the deposit, an average rate can also be determined. These methods are considered direct monitors since they attempt to measure the actual films deposited on parts. These approaches have a critical drawback. Measurement can only take place after a deposition is finished and resolution may be inadequate. Clearly, it is desirable to be able to make such measurements in the chamber so the deposition can be monitored and adjusted, if required.

To measure film thickness during deposition, other techniques are required. An indirect monitor can be placed in the chamber which will measure the amount of deposition on its own surface, not the surface of an actual part. This allows for monitoring during the actual deposition. There are several types of indirect monitors, the one we discuss here is the quartz crystal film thickness monitor.

The quartz crystal monitor operates on a principal called the piezoelectric effect. When a free-running RF voltage is applied to a quartz crystal, it vibrates at its natural frequency. At a constant temperature, this frequency remains stable unless the crystal's mass changes. Depositing a thin film on the crystal's surface will change the mass of the crystal. The increase in mass from the deposition causes the resonant frequency of the crystal to

lower. Such changes are easily detected electronically and converted into thickness measurements. By electronically measuring at short intervals, a rate of deposition can be computed. It has been determined that it is more accurate to monitor the crystal's changing period (time per vibration) than its changing frequency (vibrations per second). Today's digital circuitry makes it easy for modern crystal monitors to use the crystal's changing period as the basis for thickness measurements.



Since heat also changes the frequency of the vibration of the crystal, the monitor must be water-cooled to provide accurate readings. Since the quartz crystal device is an indirect monitor, it gives an accurate indication only of the film thickness on the crystal itself. This may not be a true representation of the thickness of the film being deposited on actual parts. The placement of the monitor is crucial to the accuracy of the results. This can be a problem in an environment where parts are being rotated to cover multiple surfaces. If the crystal always faces the deposition source, it will show a reading much higher than what is actually being deposited on any given surface of the part.

The crystal loses accuracy as deposits build up on it. The deposits on the crystal surface form stresses which will eventually cause the crystal to fail. It must then be replaced with a new one at a cost of about \$10. Modern electronic controllers are able to monitor some of the changes crystal undergoes during use and account for them, thereby increasing the useful life of the crystal. Shutters can be used to prevent accumulation on the crystal surface when monitoring is not required.

An electronic controller is required to interface with the user, to interpret the signal from the crystal, and to regulate the rate of the deposition. The electronic controller plays an important role in the performance of the system, especially when it is used to automatically control deposition rates. Modern controllers are accurate for many different materials, including alloys. Some even allow for storage of programs, enabling deposition parameters to be instantly available as required.

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