Technical Bulletin

What Exactly is a Quartz Crystal?

A quick glance at quartz crystals and the theory behind thin film deposition

INFICON is a worldwide supplier of replacement quartz crystals for most thin film monitors and controllers. As many film process engineers and operators know, the quartz crystal is the key to a successful deposition run. Quartz crystals open a window on the coating process, reveal the thickness of material deposited on the substrates, and convey the rate, or thickness per second, that is being evaporated. This information is in turn used to control the power supply to the evaporation source allowing precise control of the coating process from beginning to end. When the crystal fails, however, the window abruptly shuts, leaving the operator in the dark and potentially terminating the coating run. With a potentially destructive impact from such a small, inconspicuous item, the question must be asked, "What exactly is a quartz crystal sensor?"

The thin circular crystal that is eventually placed in the sensor head originates as a multifaceted bar of quartz that is shaped like a sparkling, six-sided rod. Through a series of machining and milling, the bar is eventually converted to a stack of thin (approximately ten thousands of an inch thick) circular wafers. Each wafer is then contoured on one side and cleaned. Finally, the wafer is coated with a thin metal film, edge-to-edge on one side, and a pattern on the backside. After final inspection to determine electrical properties, the crystals are packaged in an indexable container and shipped to the end user.

The real mystery, however, is how this thin, tiny disc actually works. It was first discovered that certain crystalline materials, like quartz, would develop an electrical charge, like a battery, when pressed or squeezed. This property came to be known as the piezoelectric effect (pronounced "pea-a-zo"). Conversely, if a battery were connected to the crystal, the crystal would change by stretching or compressing. If the battery were then turned on and off quickly, in rapid succession, the crystal would vibrate.

In the 1950s, a German scientist named George Sauerbrey, showed that the vibration of a quartz crystal could be slowed down by depositing a thin coating on the crystal's surface. It was found that the change in this vibration or frequency, was a function of the thickness and the density of the coating. Using sophisticated electronics, this could be calculated many times per second, giving a real-time measurement of the thickness of the coating being deposited on the crystal, representative of any object in its vicinity.

And with that, the thin film monitor was born.