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X-RAY FLUORESCENCE FOR MEASURING PLATING THICKNESS

1. PURPOSE

There are a number of techniques currently being used for measuring plating thickness. All have peculiar application and also limitations. Basic economics, however, demands that for measuring gold thicknesses in the commonly used plating thickness ranges, a system must be highly reliable, accurate, repeatable and fast. Over the past several years X-ray Fluorescence systems, more than any other, have been found to meet that requirement. There are, however, many facets of operation involved with x-ray techniques with which the operator should be acquainted. The purpose of this paper is to highlight these subtleties so that x-ray users are aware of them and can implement procedures for their instrument operation which will provide measurements of highest possible levels of accuracy and repeatability.

2. INTRODUCTION

X-rays are electromagnetic waves, generally thought of as particles of light or photons of very high energy levels. They travel at a very high frequency and are of short wave length. X-ray radiation occurs naturally, such as in the form of a radioisotope or can be generated artificially as in an x-ray tube. The advantage of an x-ray tube is that it produces a high x-ray flux which does not decay and is generated only as long as power is applied. The radioisotope in contrast cannot be turned off and unless a large quantity of the material is used, it generates only a small flux of x-rays.

Consequently, the x-ray tube is the more stable and safest system for generating x-rays in applications for measuring plating thickness. This is accomplished in the tube by applying a high voltage across the gap between a heated cathode filament and a tungsten target causing the electrons to bombard the target at high energies which in turn emits x-rays. In application these incident x-rays must be focused into a fine beam capable of being directed into extremely small areas. This is done by passing the x-rays through a long narrow tube made with strongly absorbing or reflective walls which permit only radiation traveling parallel to the tube axis to traverse its entire length. This tube, known as a "Collimator", can direct x-rays in a beam as narrow as 0.08 mm (.003") in diameter, allowing access to very small areas.

3. X-RAY FLUORESCENCE

The atoms which make up an element consist of a central nucleus surrounded by electrons orbiting the nucleus at various energy levels, known as shells. If an incident photon, a quanta of energy, strikes an electron in a given shell that electron will gain energy from the striking photon and becomes excited. In this state it leaves the atom, creating a vacancy in the shell from which it originated. To fill the vacancy an upper level electron, one with a higher energy will fall into the vacancy. The excess energy which this electron possesses will then be released as the emission of a photon, in this case, an x-ray photon. This is known as x-ray fluorescence.

Each atom possesses an electron distribution and arrangement peculiar to itself, see Periodic Table, page 7. The energy of the fluoresced x-rays for a given emission line increases with the atomic number of the particular atom. In other words, the wave length or energy of the fluoresced x-rays characterizes the particular atom emitting them. So, it can then be seen that by examining the distribution and energies of the fluoresced x-rays from materials, the nature of these materials may be determined. Further, by the monitoring of the relative quantities or intensities of the x-ray fluorescence throughout the spectrum the proportional quantities of the materials present can be determined as well.