NASA TECH BRIEF

Lewis Research Center

Method of Measuring the Thickness of Radioactive Thin Films

The Problem:

To measure the thickness of a titanium tritide film, used as a target for neutron production. Measurement of the thickness of non-radioactive thin films on a substrate has been accomplished for a variety of materials by excitation of the characteristic x-rays of the substrate with a radioactive source and measurement of the absorption of the x-rays by the thin film. With a titanium tritide film, the x-ray background created by the radioactive decay in the film itself complicates the thickness measurement. Further complications existed because of the presence of a background radiation in the neutron generator.

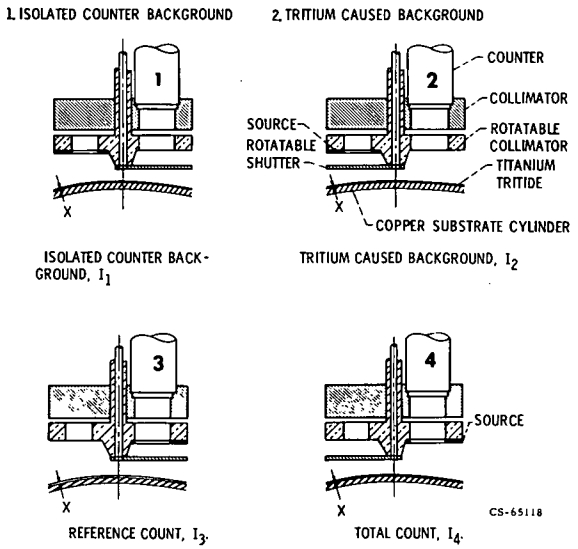
The Solution:

A thickness monitor was developed which consists of a proportional x-ray counter coupled to a pulse counting system, a copper filter over the face of the counter, a rotatable collimator containing the radioactive source, and a rotatable shutter. The rotatable collimator and shutter allow for the following separate measurements: (1) the tritium caused x-ray background from a titanium tritide film coated onto a copper substrate; (2) the 8 keV x-rays excited in the uncoated copper substrate that are caused by a cadmium-109 source; (3) the proportional counter x-ray background with the counter isolated from both tritium and cadmium-109 caused radiation; and (4) a total x-ray count due to all of these sources. From these measurements, the number of 8 keV x-rays excited in the substrate by the cadmium-109 source and transmitted through the titanium tritide film can be calculated. This number constitutes a measure of the film's thickness. The copper filter passes the 8 keV x-rays while absorbing the majority of the background x-rays.

The thickness monitor can be used as an integral part of a neutron generator. It has been used to measure titanium tritide film thicknesses from 0.1 to 30 micrometers.

How It's Done:

The method of measuring film thickness is illustrated in the figure which shows four rotatable collimator and shutter positions. Three separate x-ray counts are required



for each thickness measurement. A fourth count, obtained with the monitor configuration 1 in the figure, is the isolated counter background count. This count, I_1, is independent of the radioactive cadmium source or the tritium film, and, therefore, this measurement is not necessary for every thickness determination.

Monitor configuration 2 is used for measurement of the tritium-caused background intensity, I_2. The radioactive source is isolated so that only tritium-caused x-rays are counted.

Monitor configuration 3 is used for measurement of count rate, I_3. The rotatable shutter, when positioned beneath the source and counter, provides a copper reference surface for generation of 8 keV x-rays. The 8 keV x-ray intensity, I_{OS}, due to the radioactive cadmium source is then calculated from the equation:

$$I_{OS} = I_3 - I_1$$

(continued overleaf)

Intensity I_{OS} is related to the intensity of x-rays from the uncoated copper target substrate, I_{OT}, by a constant factor of 1.46. This factor is a function of the different source-counter geometry involved for the intensity measurements of I_{OS} and I_{OT}. The factor was measured as a ratio of I_{OS}/I_{OT} for the uncoated copper substrate and copper reference shutter of the monitor.

Monitor configuration 4 is used for obtaining a count rate, I_4. Subtraction of the tritium-caused background, I_2, from I_4 results in the number of 8 keV x-rays transmitted through the film, I_x, where:

$$I_x = I_4 - I_2$$

The fraction of 8 keV x-rays transmitted through a titanium tritide film is:

$$\frac{I_x}{I_{OT}} = \left(\frac{I_x}{I_{OS}}\right)\left(\frac{I_{OS}}{I_{OT}}\right)$$

$$\frac{I_x}{I_{OT}} = \left(\frac{I_x}{I_{OS}}\right) 1.46$$

where I_x is the intensity of 8 keV x-rays transmitted through a titanium tritide layer of thickness X; I_{OT} is the 8 keV x-ray intensity from the uncoated copper target substrate; and I_{OS} is the 8 keV x-ray intensity from the rotatable copper shutter.

The fraction of 8 keV x-rays transmitted through the tritide film can be related to the thickness of the film by the exponential equation:

$$\frac{I_x}{I_{OT}} = e^{-kx}$$

where k is the absorption coefficient for the film and x is the thickness of the film.

Use of the reference shutter count permits determination of both I_x and I_{OT} for each thickness measurement. Therefore, changes in counting system amplifier gain, source decay, and other long-term variables are eliminated.

Notes:

1. The monitor described should have broad application for the measurement of the thickness of any radioactive thin films.
2. Further information is available in the following report:
   NASA TM-X-68170 (N73-15475), An X-Ray Monitor for Measurement of a Titanium Tritide Target Thickness
   Copies may be obtained at cost from:
   Aerospace Research Applications Center
   Indiana University
   400 East Seventh Street
   Bloomington, Indiana 47401
   Telephone: 812-337-7833
   Reference: B74-10065
3. Specific technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B74-10065

Patent Status:

NASA has decided not to apply for a patent.

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