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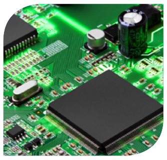

# Total Reflection X-ray Fluorescence (TXRF) Services

**Total Reflection X-ray Fluorescence (TXRF) is a highly surface-sensitive technique, optimized for analyzing surface metal contamination on semiconductor wafers such as Si, SiC, GaAs or sapphire.**

Total Reflectance X-Ray Fluorescence (TXRF) is a survey technique that provides the identity and concentration of trace element contaminants on semiconductor wafers. It utilizes an extremely low angle x-ray, which is below the critical angle of the substrate, to limit excitation to the top ~80 Å of the wafer surface (depending on the material).

The incident beam x-ray will reflect off the sample and excite impurity atoms on or near the surface. This excitation will eject an inner-shell electron of an atom, which will create an electron hole. This hole is then filled by an outer shell electron dropping down in energy to take its place, and the energy is released as a fluorescent x-ray photon. This fluorescent x-ray is then captured by the detector and its measured energy is characteristic of the element which it came from. The intensity of the x-ray fluorescence is used to quantify the areal density (effectively the surface concentration) of that species.

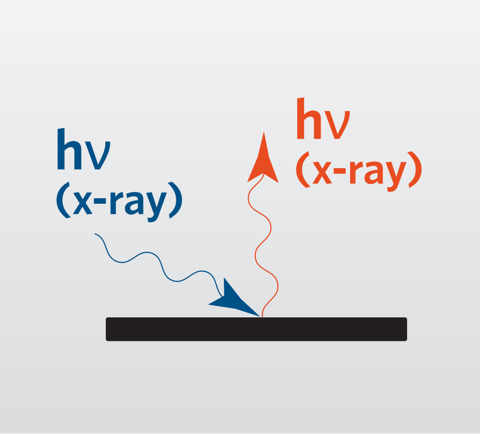

*Figure 1: General schematic of how TXRF works*

## Strengths

- Trace element analysis
- Survey analysis
- Quantitative
- Mapping options
- Non-destructive
- 1cm$^2$ spot size
- Whole wafer analysis (up to 300 mm)
- Partial wafer analysis (50mm x 50mm pieces or larger)
- Can analyze many substrates or films, such as Si, SiC, SiN, GaAs, GaN, InP, Cu, Ge, Nb, sapphire, and glass
- ZEE (zero edge exclusion) measurements possible on 300mm and 200 mm wafers

## Limitations

- Cannot detect low-Z elements (H-Ne)
- Spectral interferences can limit element quantification in some cases
- Polished surface required
- Non-patterned wafers required for accurate quantification of surface-level contaminants
- Sample thickness below 2 mm required
- Sample size at least 50mm x 50mm required
- Higher detection limits for lighter elements or low Z

## Common Applications

- Contamination check of processed wafers (implant, CMP, etch, thermal, CVD, etc.).

- Comparison of surface contaminants before and after processing or process changes.
- Mapping of contamination across entire wafer surface.
- Analysis of backside to assess backside contamination (polished backsides only, or flipped wafers).

## Industry Sectors and Technologies

- Semiconductor equipment and materials
- High power electronics
- Communications
- Optoelectronics

## Case Study: Sensitivity of TXRF

To demonstrate the sensitivity of TXRF, measurements were taken on a bare Si wafer before and after the wafer was in contact for ten seconds with a 25¢ coin. Quarter dollars are approximately 75% Cu and 25% Ni on the outer surface, so it would be expected to find Cu and Ni contamination in roughly these ratios. In the spectra below, both Cu and Ni contamination were found to be present after contact was made. The ratio between the contaminants was determined to be 67% Cu and 33% Ni.

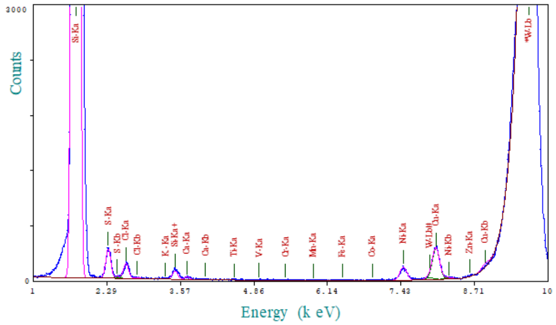

*Figure 2: The data confirms that both Cu and Ni contamination were found to be present after contact was made.*

## Case Study: Mapping of TXRF

To demonstrate the mapping potential of TXRF, a similar case study was performed using a stainless-steel ruler. Mapping measurements were taken before and after the wafer surface was in contact with the ruler for ten seconds at the 10 o'clock position. For contact with stainless steel, one would expect to find Fe, Cr, and other potential metal contaminants. Figure 3 shows the distribution of Fe contamination measured on the wafer. Similar maps were generated for Cr, Mn, Ni, and other trace metals.

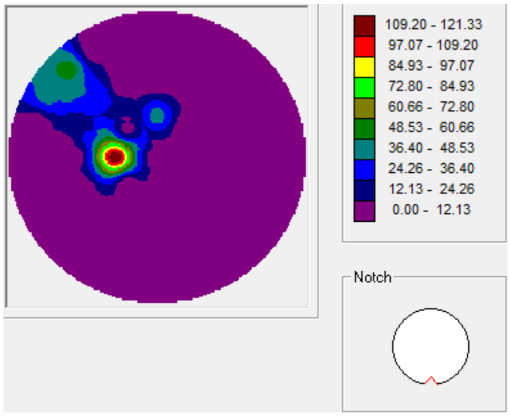

*Figure 3: Distribution of Fe contamination on the wafer.*

## Complementary Techniques

VPD-ICP-MS can provide a general average elemental survey of wafer contaminants (including low-Z elements not detectable by TXRF), but requires sample preparation, is destructive to samples, and is dependent on the substrate surface/film going into solution. Additionally, it is not location-specific, so mapping is not possible. SIMS can provide a depth profile of elemental composition, but is destructive to samples. AFM can provide surface topography data for the wafer surface.

## TXRF at EAG

At Eurofins EAG, our TXRF tool is housed in a class 10 clean room to minimize the risk of cross-contamination or issues caused by environmental particles in standard lab air. There is minimal handling of wafers. 300mm wafers in a FOUP can be directly loaded into the instrument. Every spectrum and quantification data set are verified by two experienced analysts as we work closely with our clients to tailor our analysis protocols to their needs. Contact us today to learn how we can help.