

EDXRF VS WDXRF

Written by Skyray Instruments

In an effort to save money, space, sample preparation time, or simply to add an analytical instrument to their process many companies will decide to evaluate energy dispersive x-ray fluorescence (EDXRF) analysers as a substitute for their standard wavelength dispersive x-ray fluorescence (WDXRF) analysis. This is very common with geological applications where WDX is the benchmark, but it occurs with many other applications as well. What all these companies eventually discover is that EDXRF is not the low cost drop in replacement that they thought it would be but has significant differences, some positive and some negative, that must be considered in the evaluation process or else dealt with later when it may be less convenient.

More than just the backwards spectra

As most scientifically minded persons know, the energy of the light photon increases as the wavelength decreases, so in an EDX spectra the low atomic number elements are on the left while they are to the right of a WDX spectra. But the difference goes far beyond that.

WDXRF

The WDXRF analyser uses the x-ray source to excite a sample. X-rays that have wavelengths that are characteristic to the elements within the sample are emitted and they along with scattered source x-rays go in all directions. A crystal or other diffraction device is placed in the way of the x-rays coming off the sample. The x-ray detector is position where it can detector the x-rays that are diffracted and scattered off the crystal. Depending on the spacing between the atoms of the crystal lattice (diffractive device) and its angle in relation to the sample and detector, specific wavelengths directed at the detector can be controlled. The angle can be changed in order to measure elements sequentially, or multiple crystals and detectors may be arrayed around a sample for simultaneous analysis.

EDXRF

The EDXRF analyser also uses an x-ray source to excite the sample but it may be configured in one of two ways. The first way is direct excitation where the x-ray beam is pointed directly at the sample. Filter made of various elements may be placed between the source and sample to increase the excitation of the element of interest or reduce the background in the region of interest. The second way uses a secondary target, where the source points at the target, the target element is excited and fluoresces, and then the target fluorescence is used to excite the sample. A detector is positioned to measure the fluorescent and scattered x-rays from the sample and a multichannel analyser and software assigns each detector pulse an energy value thus producing a spectrum. Note that there is absolutely no reason why the spectra cannot be displayed in a wavelength dependant graph format.

Points of Comparison

1. **Resolution:** It describes the width of the spectra peaks. The lower the resolution number the more easily an elemental line is distinguished from other nearby x-ray line intensities.

a. The resolution of the WDX system is dependent on the crystal and optics design, particularly collimation, spacing and positional reproducibility. The effective resolution of a WDX system may vary from 20eV in an inexpensive benchtop to 5eV or less in a laboratory instrument. The resolution is not detector dependant.

b. The resolution of the EDX system is dependent on the resolution of the detector. This can vary from 150eV or less for a liquid nitrogen cooled Si(Li) detector, 150-220eV for various solid state detectors, or 600eV or more for gas filled proportional counter.

ADVANTAGE WDXRF?

High resolution means fewer spectral overlaps and lower background intensities.

ADVANTAGE EDXRF?

WDX crystal and optics are expensive, and are one more failure mode.

2. **Spectral Overlaps:** Spectral deconvolutions are necessary for determining net intensities when two spectral lines overlap because the resolution is too high for them to be measured independently.

a. With a WDX instrument with very high resolution (low number of eV) spectral overlap corrections are not required for a vast majority of elements and applications. The gross intensities for each element can be determined in a single acquisition.

b. The EDXRF analyser is designed to detect a group of elements all at once. The some type of deconvolution method must be used&nb

Wavelength Dispersive X-ray Fluorescence

Written by Skyray Instruments

Introduction

Wavelength dispersive x-ray fluorescence (WDXRF) is the old timer among commercial x-ray spectrometers, since the method works without high-resolution solid-state detectors. Instead, WDXRF instruments rely on diffractive optics to give them high spectral resolution. WDX spectrometers with simple electronic counting circuits were around well before the computer age, and are still the workhouse and leading performer for routine XRF analysis.

Hardware

WDXRF can be relatively simple and inexpensive, or complex and very expensive depending on the number of optical components. WDX instruments use a x-ray tube source to directly excite the sample. Because the overall efficiency of the WDXRF system is low, x-ray tubes in larger systems are normally rated at 1-4 kilowatts. There are some specialized low power systems that operate at 50 to 200 watts. A diffraction device, usually a crystal or multilayer, is positioned to diffract x-rays from the sample toward the detector. Diffracted wavelengths are those that satisfy the $2d\sin\theta = n\lambda$ relationship, where d is the atomic spacing within the crystal, n is an integer, and θ is the angle between the sample and detector. Other wavelengths are scattered very inefficiently. Collimators are normally used to limit the angular spread of x-rays, to further improve the effective resolution of the WDX system. Because the detector is not relied on for the systems resolution it can be a proportional counter or other low-resolution counter capable of detecting a million or more counts per second.

All the components can be fixed to form a fixed single WDX channel that is ideal for analyzing a single element. A simultaneous WDX analyzer will have a number of fixed single channels usually formed in a circle around the sample with the x-ray tube facing upward in the middle. Other WDX analyzers use a goniometer to allow the angle (θ) to be changed, so that one element after another may be measured in sequence. This type of instrument is a sequential WDX analyzer. There are also combined sequential/simultaneous instruments as well.

Applications

WDXRF can be used for a tremendous variety of elemental analysis applications. It can be used to measure virtually every element from Na to Pu in the periodic table, and some instruments can be used for quantitative or semi-quantitative work for even lighter elements. It can measure elemental concentrations ranging from a few ppm to nearly 100%. It can be used for monitoring major components in a product or process or the addition of minor additives. WDXRF is extremely popular in the geological field and is often used for measuring raw minerals, and finished products composed of minerals.

Energy Dispersive X-ray Fluorescence

Written by Skyray Instruments

Introduction

Energy dispersive x-ray fluorescence (EDXRF) relies on the detector and detector electronics to resolve spectral peaks due to different energy x-rays. It was not until the 1960 and early 1970 that electronics had developed to the point that high-resolution detectors, like lithium drifted silicon, Si(Li), could be made and installed in commercial devices. Computers were also a necessity for the success of EDXRF even if they were often as large as the instrument itself.

Hardware

EDXRF is relatively simple and inexpensive compared to other techniques. It requires an x-ray source, which in most laboratory instruments is a 50 to 60 kV 50-300 W x-ray tube. Lower cost benchtop or handheld models may use radioisotopes such as Fe-55, Cd-109, Cm-244, Am-241 or Co-57 or a small x-ray tube. The second major component is the detector, which must be designed to produce electrical pulses that vary with the energy of the incident x-rays. Most laboratory EDXRF instruments still use liquid nitrogen or Peltier cooled Si(Li) detectors, while benchtop instruments usually have proportional counters, or newer Peltier cooled PIN diode detectors, but historically sodium iodide (NaI) detectors were common. Some handheld devices use other detectors such as mercuric iodide, CdTe, and CdZnTe in addition to PIN diode devices depending largely on the x-ray energy of the elements of interest. The most recent and fastest growing detector technology is the Peltier cooled silicon drift detector (SDD), which are available in some laboratory grade EDXRF instruments.

After the source and detector the next critical component are the x-ray tube filters, which are available in most EDXRF instrument. Their function is to absorb some energies of source x-rays more than others in order to reduce the counts in the region of interest while producing a peak that is well suited to exciting the elements of interest. Secondary targets are an alternative to filters. A secondary target material is excited by the primary x-rays from the x-ray tube, and then emits secondary x-rays that are characteristic of the elemental composition of the target. Where applicable secondary targets yield lower background and better excitation than filter but require approximately 100 times more primary x-ray intensity. One specialized form of secondary targets is polarizing targets. Polarizing XRF takes advantage of the principle that when x-rays are scattered off a surface they are partially polarized. The target and sample are placed on orthogonal axes to further minimize the scatter and hence the background at the detector.

Fixed or movable detector filters, which take advantage of non-dispersive XRF principles, are sometimes added to EDXRF devices to further improve the instrument's effective resolution or sensitivity forming a hybrid EDX/NDX device.

Applications

EDXRF can be used for a tremendous variety of elemental analysis applications. It can be used to measure virtually every element from Na to Pu in the periodic table, in concentrations ranging from a few ppm to nearly 100 percent. It can be used for monitoring major components in a product or



process or the addition of minor additive. Because XRF's popularity in the geological field, EDXRF instruments are often used alongside WDXRF instruments for measuring major and minor components in geological sample.