KMÜ 396
Materials Science and Tech. I
Presentation

Energy Dispersive X-Ray, EDX and Wavelength Dispersive X-ray spectroscopy (WDX)

Prepared and will be presented by:

Ömer Vehbi Karaosmanoğlu

Gökhan Uzun

Osman Turan

Outline

* X-Ray
* What EDX & WDX is
* Usage Areas
    * History
    * Instruments
    * How it works
    * EDX-WDX comparison
        * Material Analysis
        * Advantages and Disadvantages
        * Summary
* References

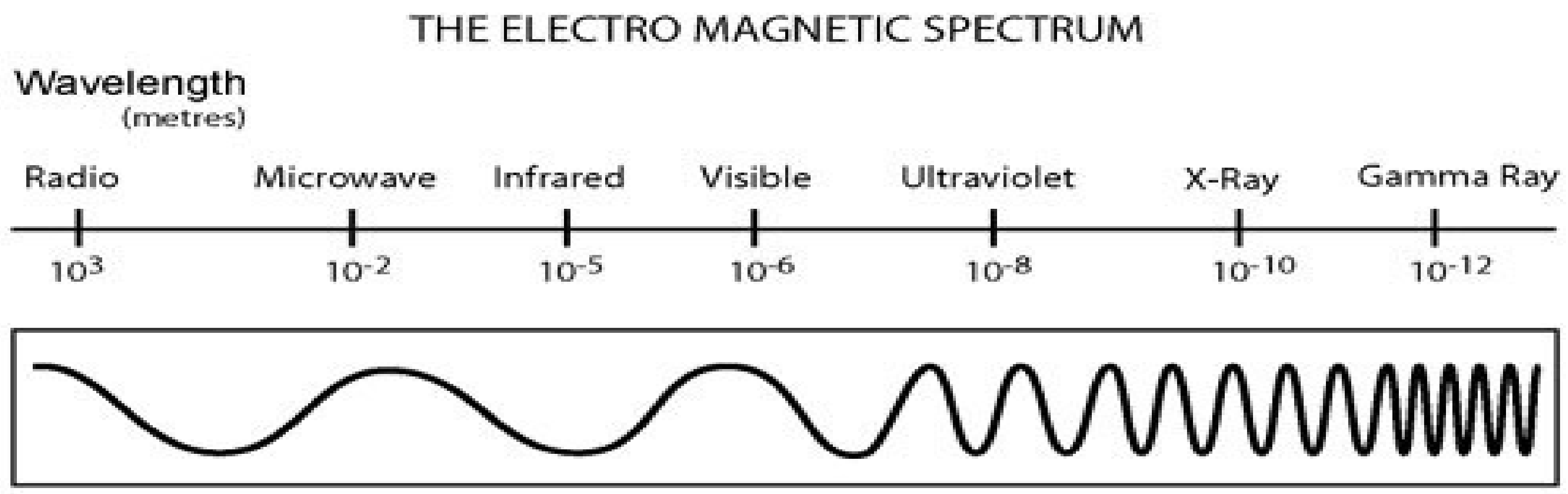
Ömer

Gökhan

Osman

*X-Ray

* A form of electromagnetic radiation
* Have a wavelength in the range of 10 to 0.01 nanometers
* Largest use is to take images of the inside of objects in diagnostic radiography and crystallography



*X-ray Spectroscopy

- Gathering name for several spectroscopic techniques
- Determining the electronic structure of materials by using x-ray excitation.

* Types of X-ray spectroscopy

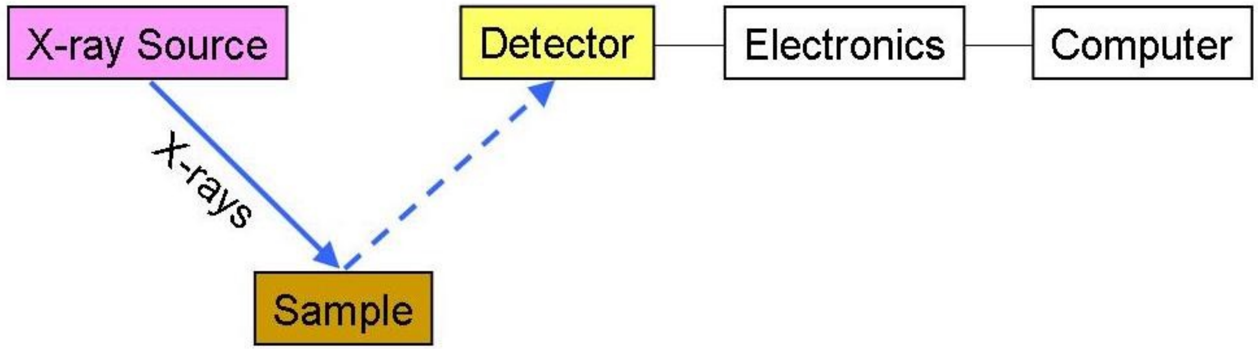
* X-ray emission spectroscopy or X-ray fluorescence (XRF)**
* Identification and measurement of concentration of elements
* X-ray absorption spectroscopy
* A widely-used technique for determining the local geometric and/or electronic structure of matter.
* X-ray magnetic circular dichroism
* A difference spectrum of two x-ray absorption spectra (XAS) taken in a magnetic field

*EDX and WDX

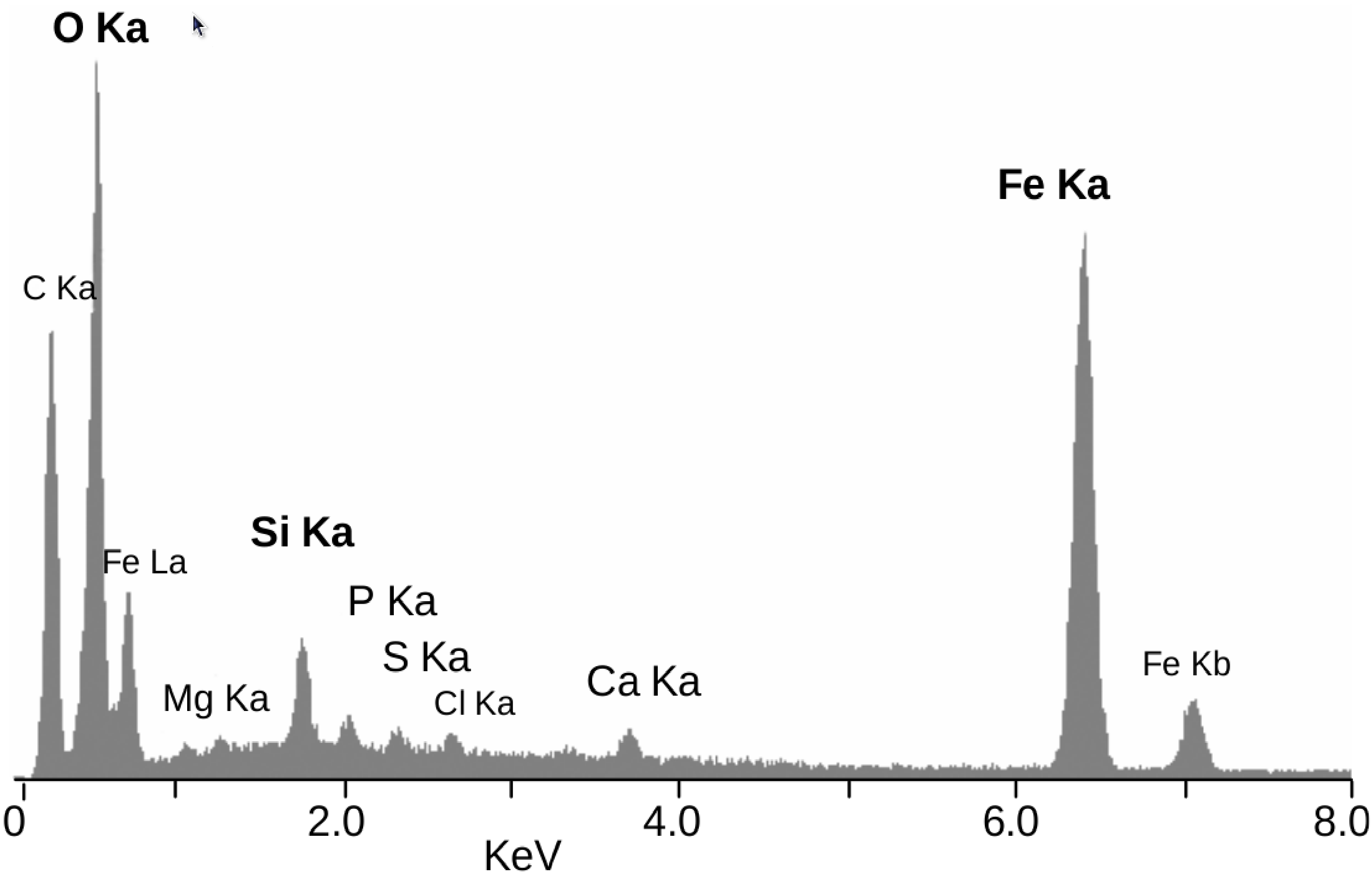
* Variants of X-ray fluorescence (XRF) or X-ray emission spectroscopy
* Chemical analysis methods of this spectroscopy
* Used in conjuction with each other

*What is EDX ?

* Energy dispersive X-ray spectroscopy (EDS or EDX)
* Analytical technique used for the elemental analysis
* Technique used for chemical characterization of a sample
* Investigation of a sample
* Analyzing X-rays emitted by the matter
* Full quantitative analysis showing the sample composition

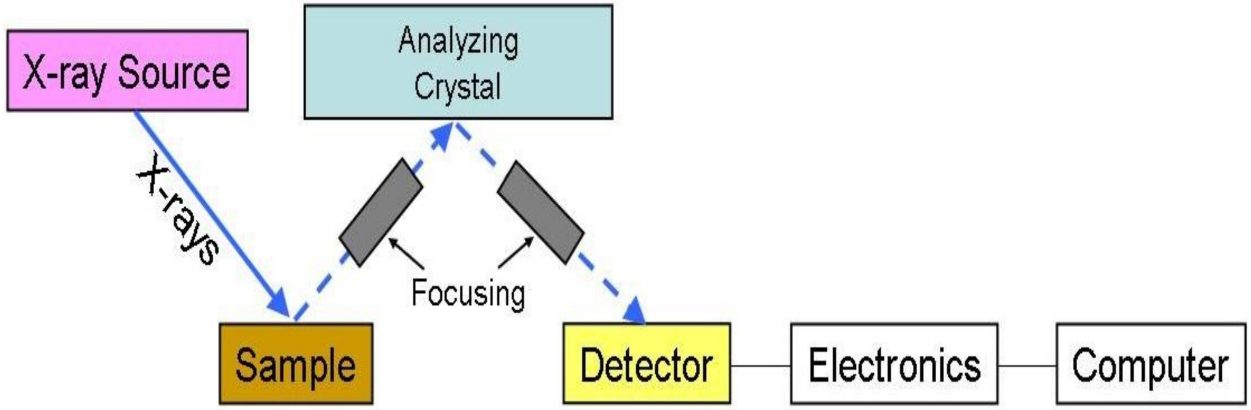


* EDX spectrum of the mineral crust of Rimicaris exoculata (bacteria)



*What is WDX ?

* Wavelength dispersive X-ray spectroscopy (WDXRF or WDS)
* A method used to count the number of X-rays
* Reads or counts only the x-rays of a single wavelength
* Element must be known
* Often used in conjunction with EDS



*Usage Areas of EDX

* Materials evaluation and identification
  * Contaminants
  * Elemental diffusion profiles
  * Glassivation phosphorus content
  * Multiple spot analysis of areas from 1 micron to 10 cm in diameter
* Failure analysis
  * Contamination identification
  * Unknowns identification
  * Stringer location and identification
* Quality control screening
  * Material verification
  * Plating specification and certification

*Usage Areas of WDX

Identification of spectrally overlapped elements

* S in the presence of Pb or Mo
* W or Ta in Si, or N in Ti

Detection of low concentration species (10-100 ppm)

* P or S in metals
* Contaminants in precious metal catalysts
* Trace heavy metal contamination
* Performance-degrading impurities in high temperature solder alloys

Analysis of low atomic number elements

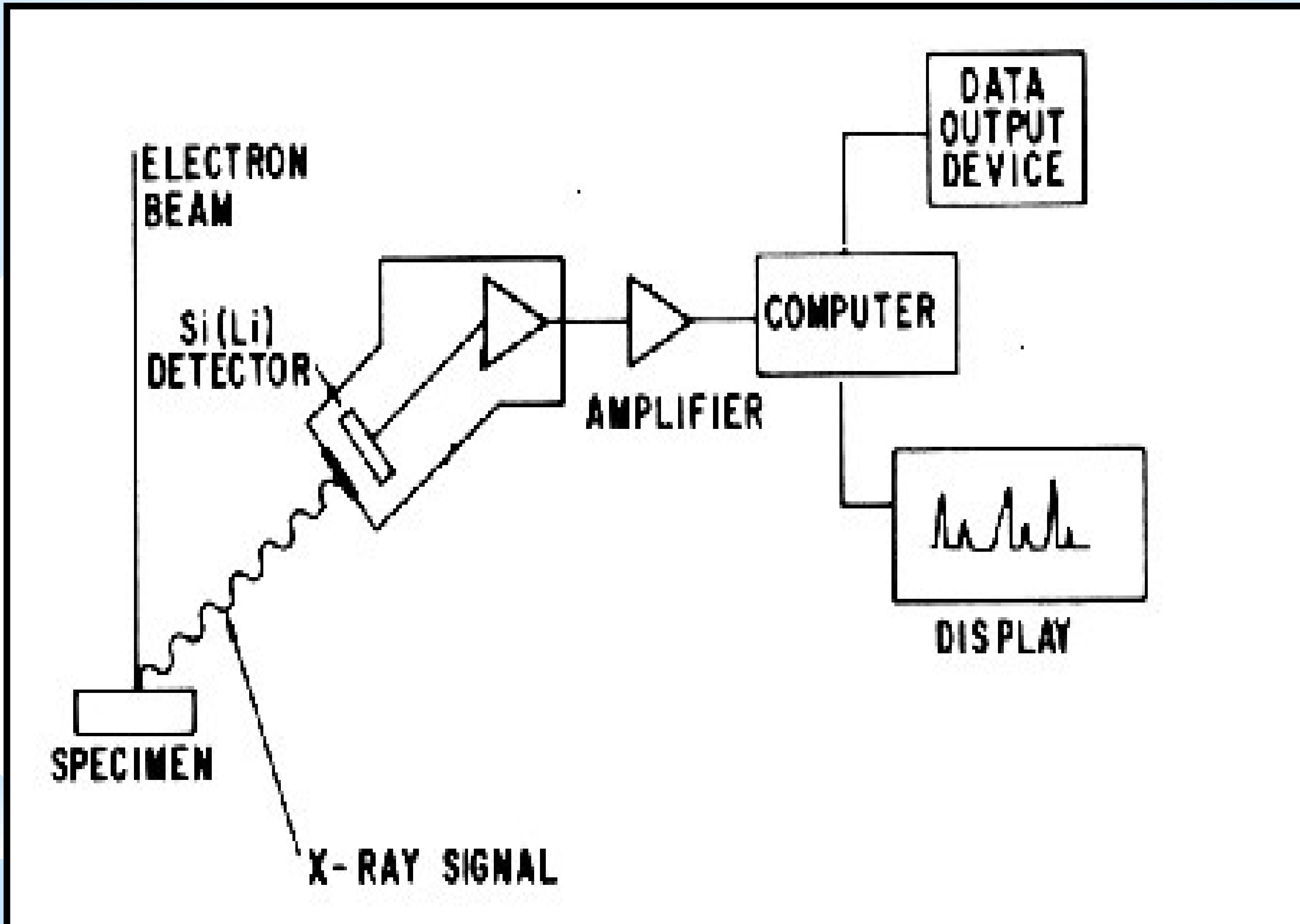
* Composition of advanced ceramics and composites
* B in BPSG films (sensitivity to 2000 ppm)
* Oxidation and corrosion of metals
* Characterization of biomedical and organically modified materials

* History of X-Ray Techniques

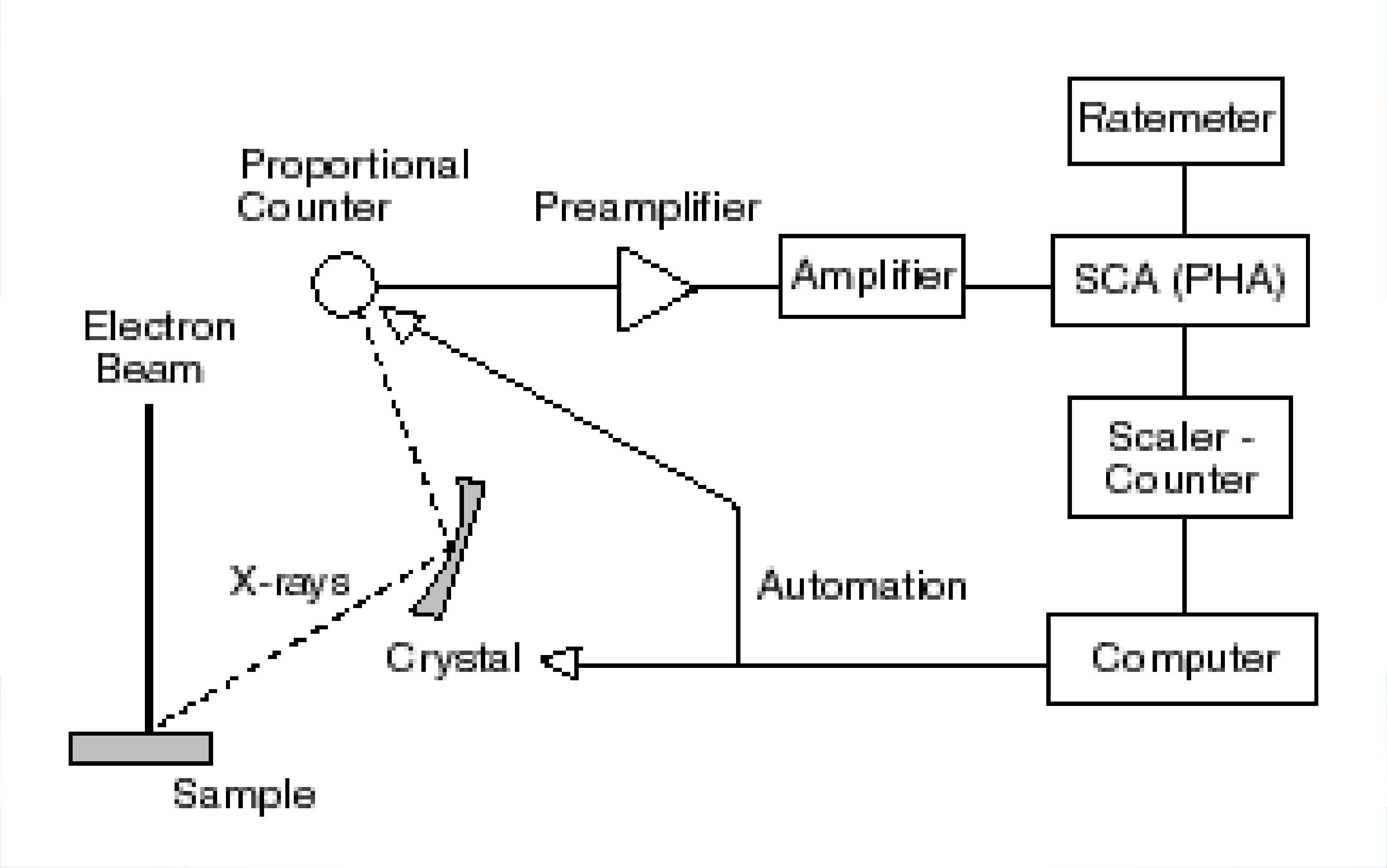
- First discovered by Wilhelm Röntgen (~1875)
- He also named X-Ray: **Röntgen rays**
- **EDX and WDX are new techniques**
- **EDX since 1950s**
- **WDX since late 1960s**

Wilhelm Röntgen, German Scientist
(1845-1923)

Energy Dispersive X-Ray Spectrophotometer (EDX) System Schematic

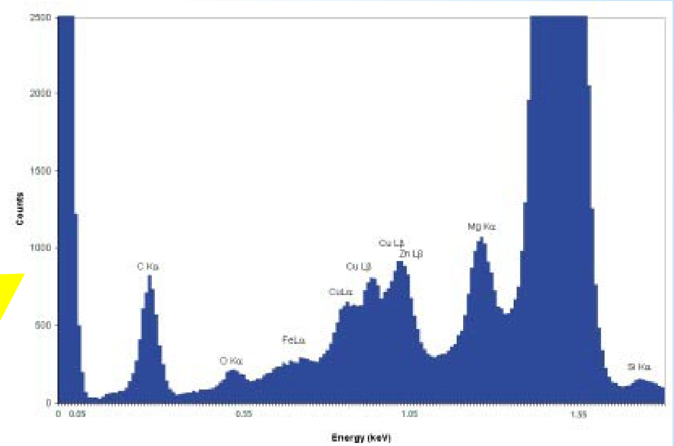


Wavelenght Dispersive X-Ray Spectrophotometer (EDX) System Schematic



X-ray Detector
Detects and converts X-rays into electronic signals

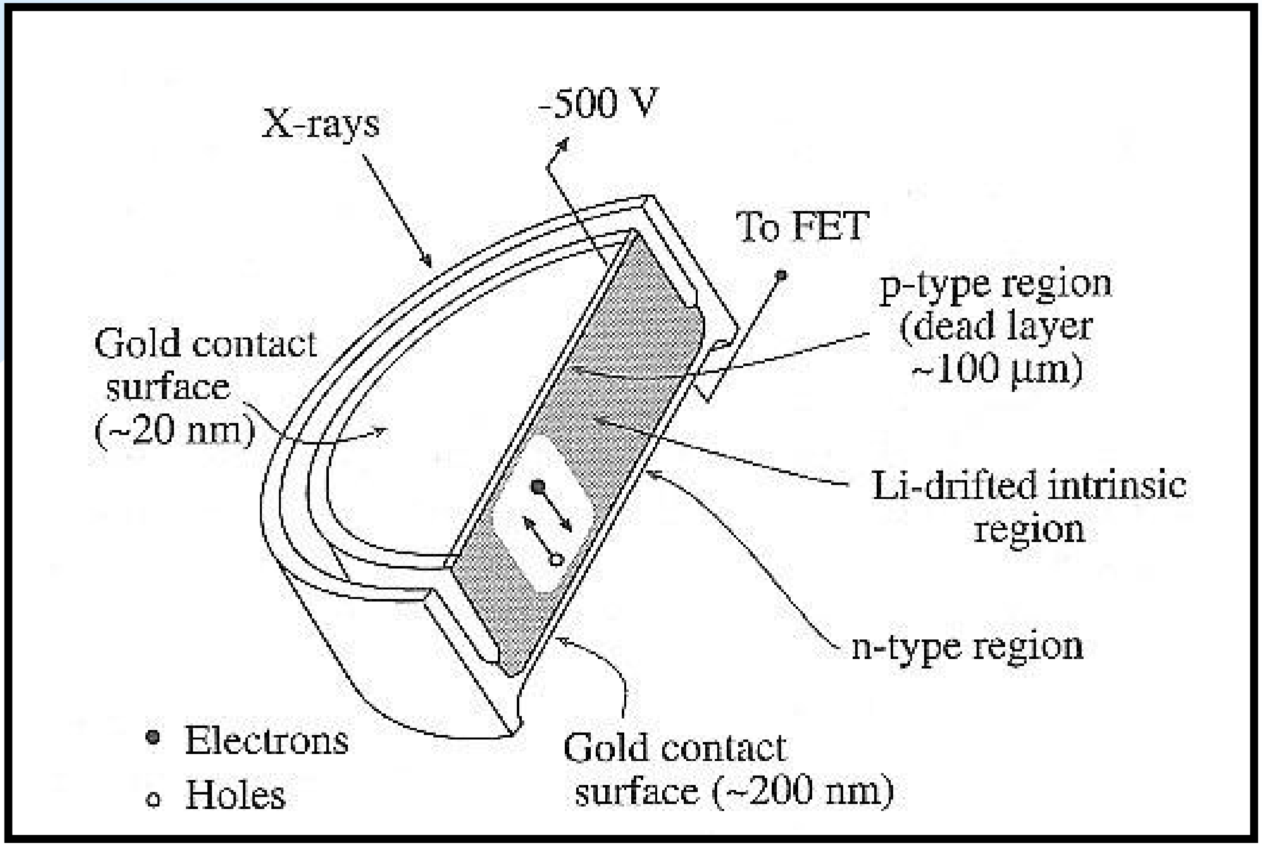
Pulse Processor
Measures the electronic signals to determine the energy of each X-ray detected



Mg	1.26 +/-	0.05	1.47
Al	89.63 +/-	0.22	94.20
Si	0.26 +/-	0.05	0.27
Mn	0.96 +/-	0.07	0.50
Fe	0.47 +/-	0.07	0.24
Ni	1.44 +/-	0.09	0.69
Cu	3.25 +/-	0.13	1.45
Zn	2.73 +/-	0.14	1.18
Totals	100.00		100.00

Analyzer
Displays and interprets the X-ray data

Detectors Are Important!



Lithium doped Silicon (SiLi) crystal detector acts as a semiconductor

* How it works ? -EDX

Obtaining EDX Spectrums

- A high-energy beam of charged particles is focused into the sample
- Ground state (unexcited) electrons in sample are stimulated
- Electrons are excited from lower energy shells to higher energy shell
- The difference in energy between the shells may be released in the form of an X-ray
- The number and energy of the X-rays emitted from a specimen can be measured by an energy dispersive spectrometer

* How it works ? -WDX

- The WDX operates in much the same way as EDX.
- Unlike the related technique of Energy dispersive X-ray spectroscopy (EDX) WDX reads or counts only the x-rays of a single wavelength, not producing a broad spectrum of wavelengths or energies.
- The crystal structure of sample diffracts the photons in principles of Bragg's law.
- Diffractions are then collected by a detector.

* EDX-WDX comparison

Spectral resolution	Higher (160 eV and less)	Lower (2-10 eV)	
Light elements?	With windowless or thin window detector	With synthetic diffractors ("crystals")	
Detection Limits	~1000-5000 ppm	<100-500 ppm	
Specifications	Cheaper, quicker but some elements are	More expensive, but with much better	
	too close together to resolve	spectral resolution	
	(eg S Ka, Mo La, Pb Ma)	giving lower detection limits.	

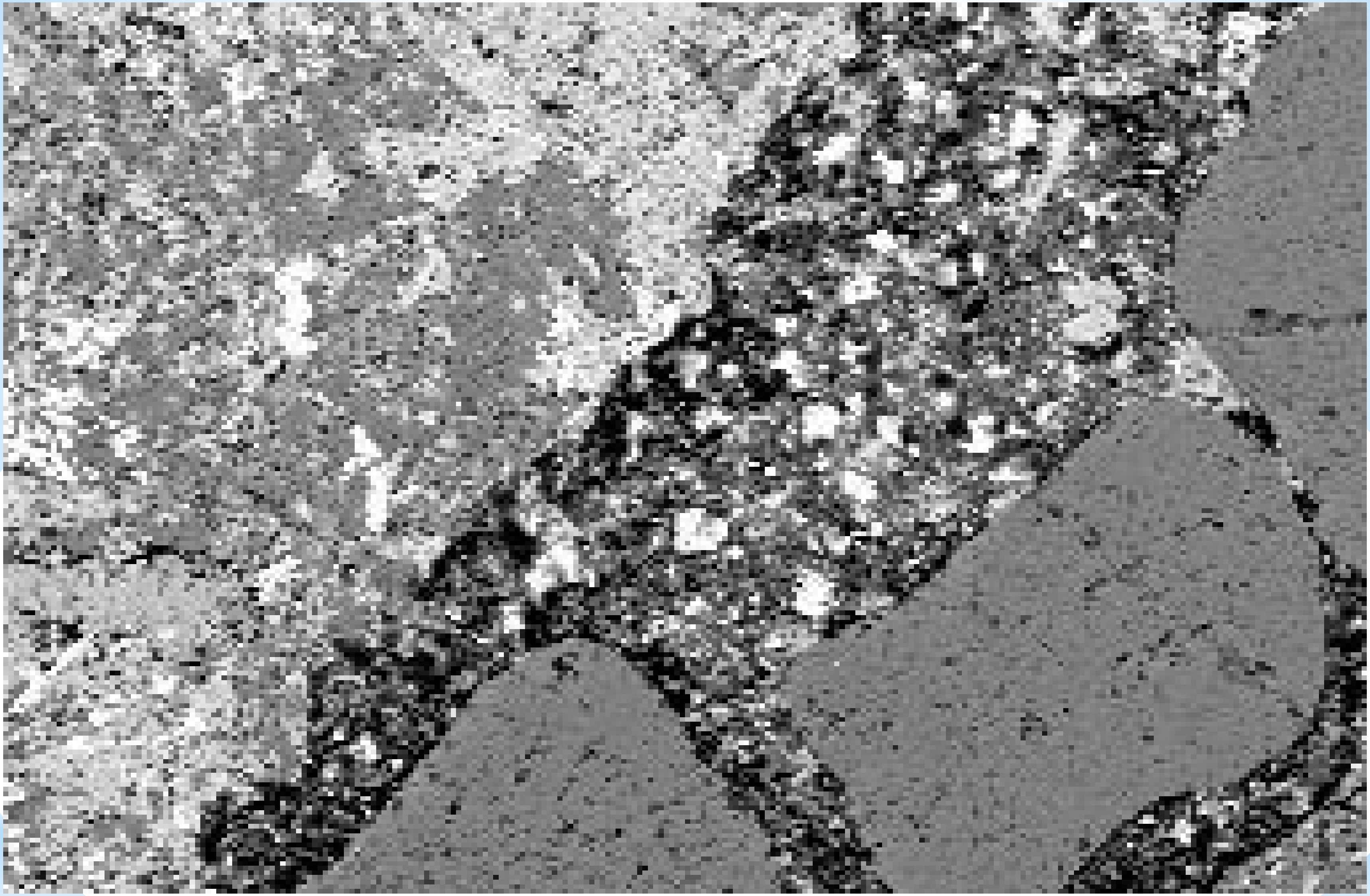
Table is adapted from : **www.geology.wisc.edu/~johnf/g777/ppt/00_What_is_777.ppt**

* What type of materials can not be tested?

* Elements like H, He, Li, or Be
* The multiple masses of an element (i.e. isotopes)

* Analysis of X-Rays

* Point analysis
* Line scanning
* Dot mapping



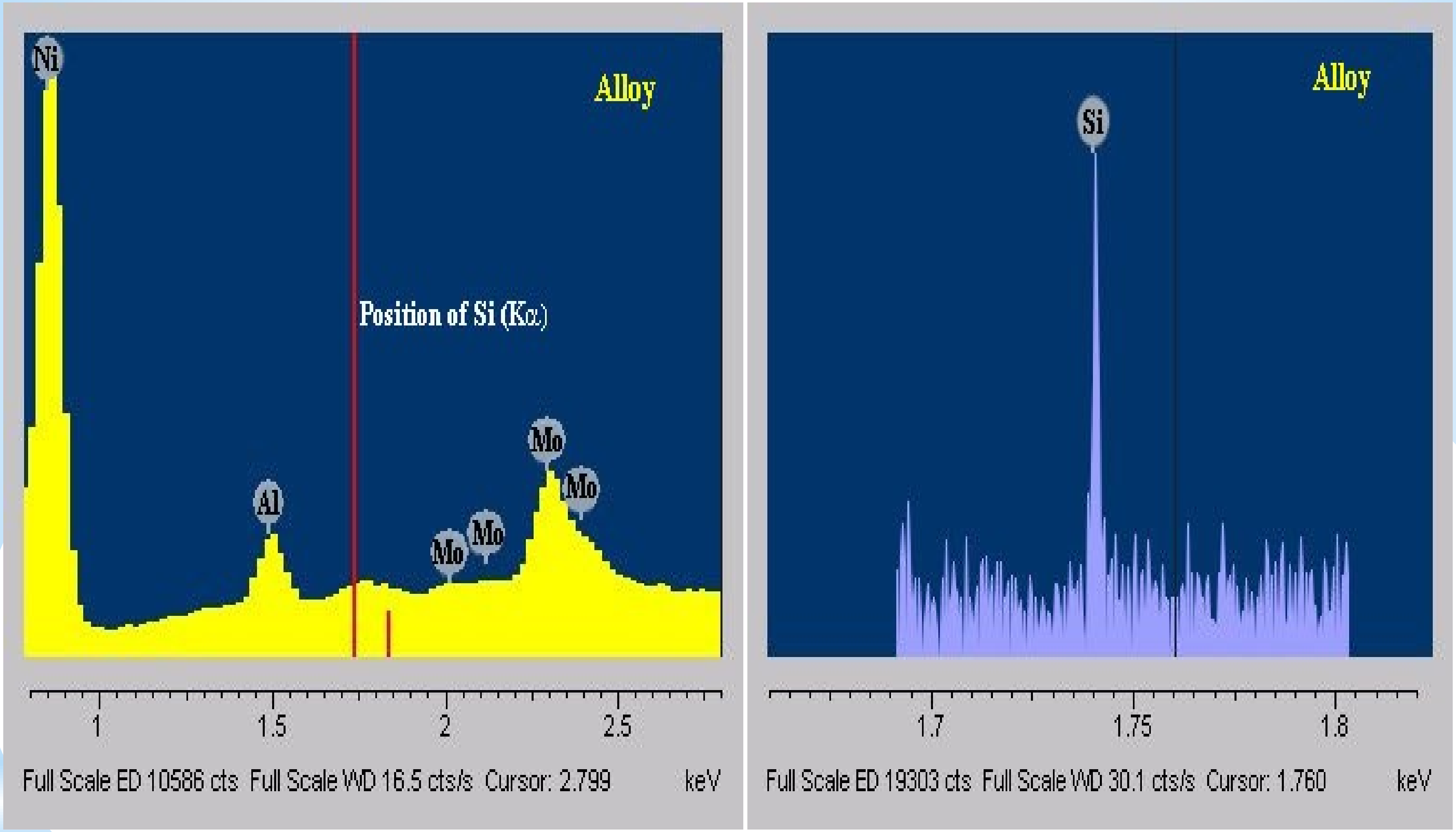
* Ref: http://www.concrete.cv.ic.ac.uk/durability/research%20techniques%20sem%20edx.htm

*Why EDX?

* Quick
* Versatile
* Inexpensive
* Widely available

*Why WDX?

* Analysis for light element
* Higher sensivity
* Lowered detection limit
* More accurate analysis
* Superior peak resolution



* Comparison of EDS (left) and WDS (right)

* http://serc.carleton.edu/research_education/geochemsheets/wds.html

Photo: A security guard is running an analysis using X-Rays ☺

Photo ref: http://www.devrimgazetesi.com.tr/resim/x%20ray%20cihaz%C4%B1%20devrede%20.JPG

*Summary

- Definitions of x-ray and x-ray spectroscopy
- A brief information about edx &wdx
- Definitions of edx & wdx and application areas
- History of edx & wdx
- How edx & wdx work
- Advantages and disavantages of edx & wdx
- Materials that could be tested by edx & wdx

*References

http://mee-inc.com/eds.html

http://www.photometrics.net/techniq.html

http://serc.carleton.edu/research_education/geochemsheets/wds.html

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