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OTHER REFERENCES

"The Esca Method using monochromatic x-rays and a permanent magnet spectrograph" by A. Fahlman et al. from Arkiv For Fysik (Sweden), Vol. 32, 1966, Paper 7, Pages 111 to 116 relied on.

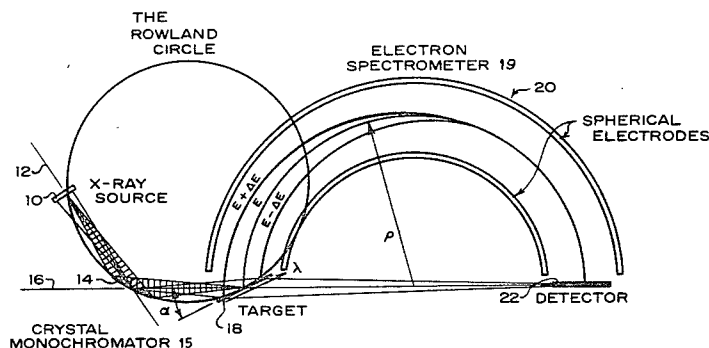
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[54] ELECTRON SPECTROSCOPY SYSTEM WITH
DISPERSION COMPENSATION
6 Claims, 3 Drawing Figs.

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[51] Int. Cl. G01n 23/22
[50] Field of Search 250/49.5
(1), 49.5 (8), 49.5 (9), 51.5, 1

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ABSTRACT: A source of X-radiation and a target under study are mounted on the Rowland circle of a monochromator so that a characteristic line in the X-ray spectrum of the source is focused by the monochromator on the target. An electron spectrometer is employed to analyze the photoelectrons emerging from the irradiated target and to focus them on a detector. The geometry of the system is arranged to make the dispersion of the monochromator equal in magnitude to and opposite in sign from the dispersion of the electron spectrometer so that these dispersions cancel out and the width of the X-ray line used to irradiate the target does not contribute to the width of the electron line detected by the detector.



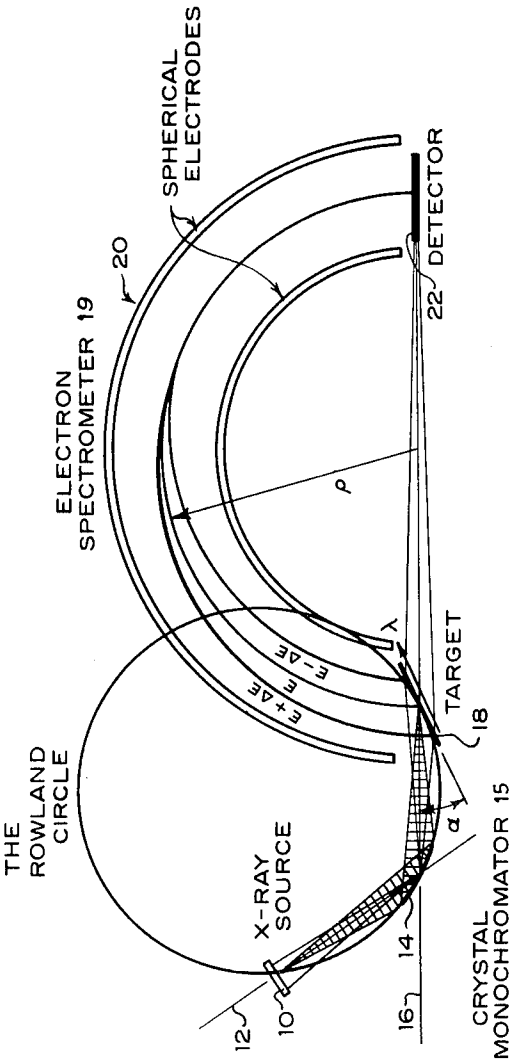


FIG. 1

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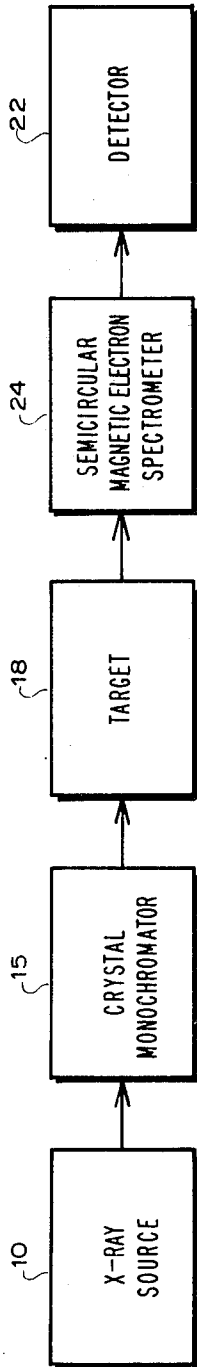


Figure 2

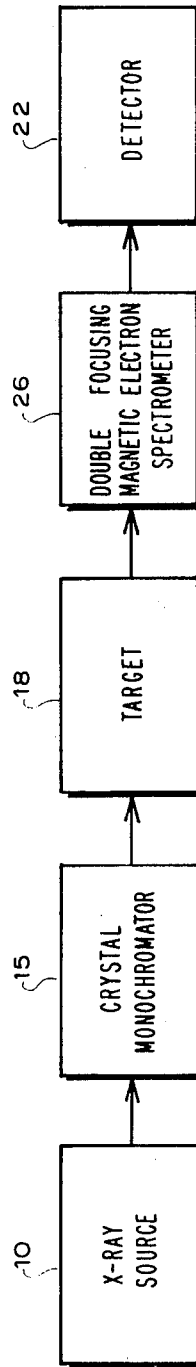


Figure 3

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ELECTRON SPECTROSCOPY SYSTEM WITH DISPERSION COMPENSATION

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to electron spectroscopy for chemical analysis (hereinafter referred to as ESCA) and, more particularly, to a dispersion-compensated system for use therein.

Typically, the main contributions to the width of an electron line in an ESCA spectrum are the inherent width of the X-ray line used to excite the electron spectrum and the inherent width of the atomic level under study. In order to obtain useful information about atoms and molecules from ESCA, the width of the electron line should reflect only the inherent width of the atomic level under study. Accordingly, it is the principal object of this invention to provide an electron spectroscopy system in which the width of the X-ray line used to excite the electron spectrum does not contribute to the width of the electron line.

This object is accomplished according to the preferred embodiment of this invention by employing a monochromator to focus a characteristic X-ray line on a target under study, by employing an electron dispersing device to analyze the photoelectrons emerging from the irradiated target, and by mounting target on the Rowland circle of the monochromator and arranging the geometry of the system so that the dispersion of the monochromator and the dispersion of the electron dispersing device cancel out.

DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic representation of a dispersion-compensated electron spectroscopy system according to the preferred embodiment of this invention.

FIGS. 2 and 3 are schematic representations of the dispersion-compensated electron spectroscopy system of FIG. 1 employing different electron spectrometers.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing, there is shown a source 10 for emitting a beam of X-radiation along a first axis 12. Source 10 may be constructed, for example, as described on pages 178—179 of the book ESCA written by Kai Siegbahn et al. and published in Dec. 1967, by Almqvist and Wiksells Boktryckeri AB (hereinafter referred to as ESCA). A dispersing crystal 14 of a crystal monochromator 15 is mounted on the first axis 12 in the path of the beam of X-radiation from source 10 for producing a spectrum of this radiation (by Bragg reflection within the dispersing crystal) and for focusing a characteristic line of this spectrum along a second axis 16 onto a target 18, the chemical composition of which is under study. Dispersing crystal 14 is provided with a curved surface so that the atomic planes have a radius of curvature equal to the diameter of the Rowland circle. Both source 10 and target 18 are fixedly mounted on the Rowland circle of the crystal monochromator with target 18 being tilted at an angle α with respect to the central ray of the incident X-radiation. An electron dispersing device, such as an electron spectrometer 19, is fixedly mounted adjacent to target 18 for analyzing the photoelectron spectrum emerging from the irradiated target and for focusing the photoelectron spectrum on a detector 22 mounted in a plane at the output end of the electron dispersing device. The electron dispersing device may comprise a semicircular electrostatic spectrometer 20, such as the one indicated schematically in FIG. 1, or (as indicated in FIG. 2) a semicircular magnetic spectrometer 24, such as the one shown and described in connection with Section VIII:3 on pages 182 et seq of ESCA. Detector 22 may comprise a photographic plate, as indicated schematically in the drawing, or a photomultiplier tube.

The finite width of the characteristic X-ray line used to irradiate the target 18 under study causes photoelectrons of the same energy level but different parts of the target to emerge with different energies. For example, as indicated in the draw-

ing, a higher energy photon strikes target 18 to the right (as viewed in the beam direction of the characteristic X-ray line) of a lower energy photon and produces photoelectrons of higher energy ($E + \delta E$) with a larger radius in the semicircular spectrometer 20 than the photoelectrons of energy ($E - \delta E$) produced by the lower energy photons. By making the dispersion of the crystal monochromator equal in magnitude to and opposite in sign from the dispersion of electron spectrometer 20, so that these dispersions cancel out, photoelectrons emerging with different energies from the same energy level but different parts of target 18 are made to arrive at the same point in the plane of detector 22. This eliminates the contribution of the width of the characteristic X-ray line to the width of the photoelectron line produced at detector 22. The dispersion of the crystal monochromator and the dispersion of electrostatic electron spectrometer 20 are made to cancel out by arranging the geometry of the system so that $\tan \alpha = (E)(D)/2p$ where E equals the photoelectron energy, p equals the radius of the central photoelectron trajectory, and D equals the crystal dispersion $dx/d(h\nu)$ with x representing distance in the direction of the emitted photoelectrons. This same condition also happens to be applicable to electron spectroscopy systems employing (as indicated in FIG. 3) double focusing magnetic electron spectrometers 26, such as those described in Sections VIII: 2 and VIII: 4 on pages 177—182 and 189—198 of ESCA. However, the condition required for the dispersion of the crystal monochromator to cancel out the dispersion of the electron spectrometer 19 must be modified for electron spectroscopy systems employing different types of spectrometers. For example, in an electron spectroscopy system employing (as indicated in FIG. 2) a semicircular magnetic spectrometer 24, such as the one shown and described in connection with Section VIII:3 of ESCA, the geometry of the system must be arranged so that $\tan \alpha = (E)(D)/p$. In most convenient systems employing such a semicircular magnetic spectrometer, α is typically about 5 to 20 degrees. The relationship necessary for dispersion compensation will also be modified if there are additional electron optical devices, such as lenses, in the system.

I claim:

1. An electron spectroscopy system comprising:

a source for producing a beam of electromagnetic radiation along a first axis;

a monochromator including a dispersing element disposed on the first axis, said monochromator being provided with a first dispersion for producing a spectrum of the electromagnetic radiation from the source along a second axis to irradiate a target mounted on the second axis and substantially on the Rowland circle of the monochromator with a characteristic line of the spectrum;

a detector; and

an electron dispersing device for focusing photoelectrons from the irradiated target on the detector, said electron dispersing device being provided with a second dispersion substantially equal in magnitude to and opposite in sign from the first dispersion of the monochromator so that these dispersions substantially cancel out to reduce the contribution of the characteristic line width to the line width of the photoelectrons focused on the detector.

2. An electron spectroscopy system as in claim 1 wherein: said source is mounted substantially on the Rowland circle of the monochromator; and

said electromagnetic radiation is X-radiation.

3. An electron spectroscopy system as in claim 2 wherein:

said monochromator comprises a crystal monochromator having a crystal dispersion D , said first dispersion being the crystal dispersion of this crystal monochromator;

said dispersing element is a crystal having a curved surface and atomic planes with a radius of curvature substantially equal to the diameter of the Rowland circle; and

said target is tilted at an angle α with respect to the beam direction of the incident characteristic X-ray line to make the crystal dispersion D of the crystal monochromator

substantially equal in magnitude to and opposite in sign from the second dispersion of the electron dispersing device so that these dispersions substantially cancel out.

4. An electron spectroscopy system as in claim 3 wherein:

said electron dispersing device is a semicircular magnetic electron spectrometer, said second dispersion being the dispersion of this semicircular magnetic electron spectrometer; and

said crystal monochromator and semicircular magnetic electron spectrometer are arranged so that tangent α equals the produce of the photoelectron energy E and the crystal dispersion D divided by the radius ρ of the central photoelectron trajectory in the electron spectrometer.

5. An electron spectroscopy system as in claim 3 wherein:

said electron dispersing device is a semicircular electrostatic electron spectrometer, said second dispersion being the dispersion of this semicircular electrostatic electron spectrometer; and

said crystal monochromator and semicircular electrostatic electron spectrometer are arranged so that tangent α equals the produce of the photoelectron energy E and the crystal dispersion D divided by twice the radius $**$ of the central photoelectron trajectory in the electron spectrometer.

6. An electron spectroscopy system as in claim 3 wherein:

said electron dispersing device is a double focusing magnetic electron spectrometer, said second dispersion being the dispersion of this double focusing magnetic electron spectrometer; and

said crystal monochromator and double focusing magnetic electron spectrometer are arranged so that tangent α equals the product of the photoelectron energy E and the crystal dispersion D divided by twice the radius ρ of the central photoelectron trajectory in the electron spectrometer.

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