Sept. 23, 1969 HIROSHI OKANO 3,469,098

X-RAY ANALYZING ELEMENT

Filed July 26, 1967 2 Sheets-Sheet 1

FIG. 1

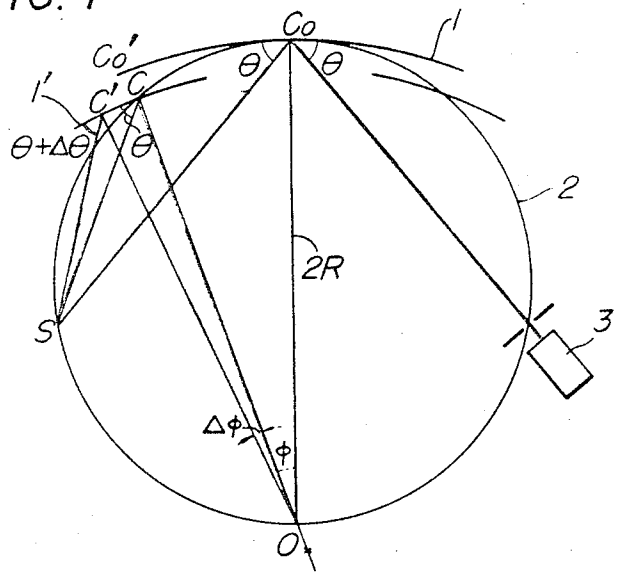
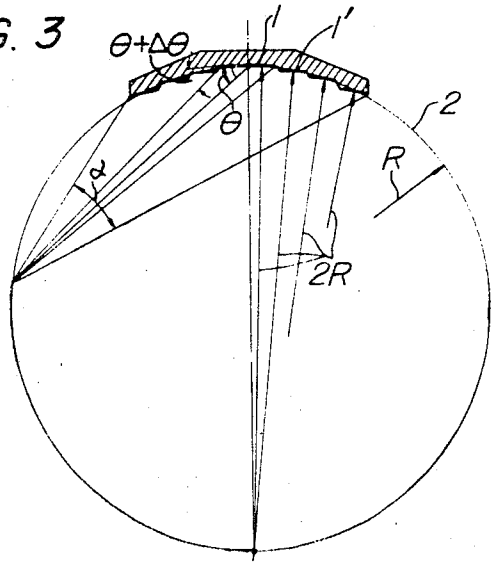


FIG. 3



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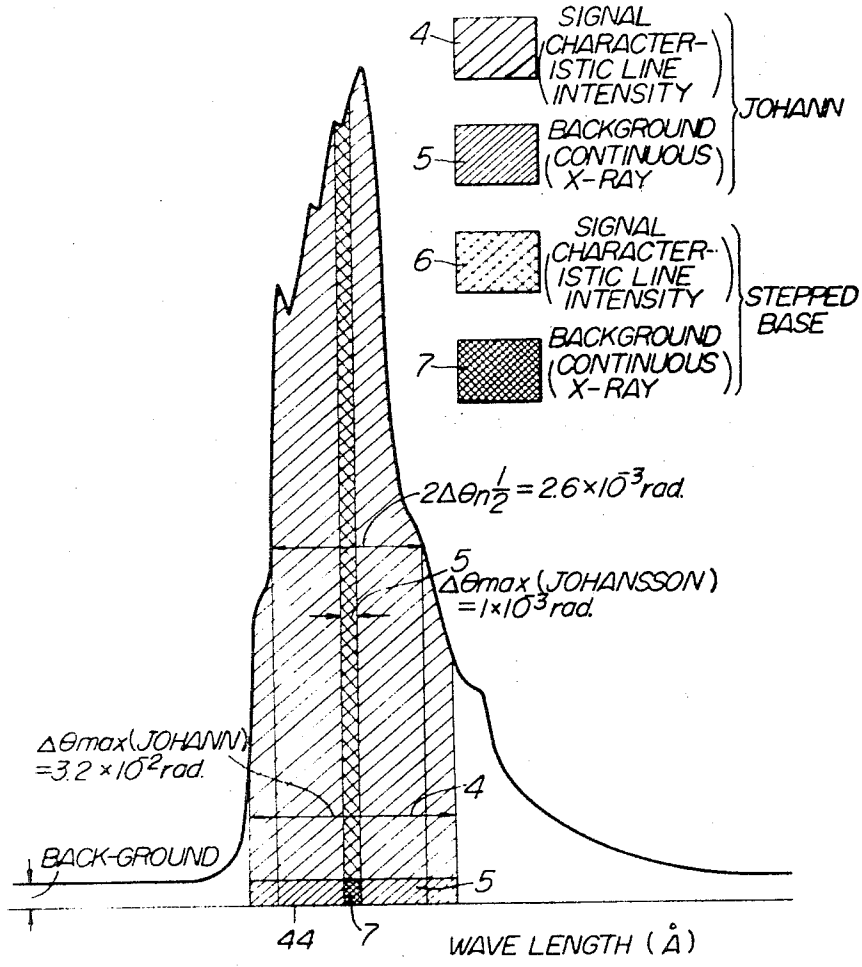
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Sept. 23, 1969 HIROSHI OKANO 3,469,098

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FIG. 2



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X-RAY ANALYZING ELEMENT

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Int. Cl. G01n *23/20;* H01j *39/10*
U.S. Cl. 250—51.5 2 Claims

ABSTRACT OF THE DISCLOSURE

An analyzing element for use in a Johansson type X-ray spectrometer having a stepped surface provided along the circumference of the Rowland circle, each step having a radius of curvature equal to twice that of the Rowland circle, whereby an analyzing element having a large area can be employed and hence a high diffraction intensity can be obtained and the peak to background ratio can be greatly improved.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to X-ray spectrometers and more particularly to analyzing elements for use in Johansson type X-ray spectrometers.

Description of the prior art

Heretofore, for the analyses of characteristic X-rays emitted by light elements such as carbon, nitrogen, oxygen, etc. a built up soap film of lead stearate or the like having a periodic structure of several ten Angstroms has been utilized as an analyzing element. In this case, as an X-ray spectrometer, that of focusing type has generally been employed in order to improve the intensity of diffracted X-rays, and the analyzing element is formed by laying a built up film on a base consisting of a part of a cylinder having a radius of curvature which is equal to the diameter of the Rowland circle.

In this focusing method, if it is assumed that X-rays are directed to a Johann type analyzing element **1** provided on a Rowland circle **2** as shown in FIG. 1, the X-rays which satisfy the Bragg's condition among those incident with an angle θ upon the point C_0 of the analyzing element lying on the Rowland circle are diffracted in a direction of θ to be detected by a detector **3** on the opposite side to the incident X-rays. X-rays directed to an edge C_0' of the analyzing element **1** satisfy only approximately the Bragg's condition to be satisfied by X-rays directed to the point C_0. This X-ray spectrometry is of a so-called Johann type focusing method.

There is another focusing method called Johannson type focusing method which is more ideal than the Johann type focusing method. However, the Johansson type focusing method, when a built up soap film is utilized as analyzing element, has not been employed because of the impossibility of preparing the analyzing element. More specifically, when a built up film is employed as an analyzing element, it has been impossible to grind the surface of the built up soap film so as to have a radius of curvature equal to the radius of the Rowland circle because the thickness of the film is of the order of several thousand Angstroms and the built up film is apt to be damaged. Excepting this difficulty the Johansson type focusing method has the advantages that by employing a large analyzing element an effective solid angle α and hence total diffracted intensity can be increased because nearly perfect diffraction and perfect focusing can be effected over a wide area of the analyzing element, and that a peak to background ratio can be improved for the analysis of primary characteristic X-rays because of a weak diffraction of continuous X-rays of adjacent wave lengths.

The surface of a so-called Johansson type analyzing crystal fits the circumference of the Rowland circle, and the atomic net plane thereof has a radius of curvature twice that of the Rowland circle as stated above. From the fact that the natural line width of incident characteristic X-rays (wave lengths: one half to several Angstroms) encountered in ordinary X-ray spectrometry is narrow and the problem of working of a crystal, a Johansson type X-ray analyzing crystal element can be provided, for example, by first bending the crystal to a curvature having a radius of curvature **2R**, where R is the radius of the Rowland circle, grinding the surface thereof to a curvature having a radius R, and then forming very fine steps of the order of molecular dimension on the surface.

When analyzing characteristic X-rays emitted by a light element such as carbon, nitrogen, oxygen, etc. by means of a built up film, even fairly coarse steps on the surface of the analyzing element may be effective, since the relative line width of the characteristic X-rays from these light elements is larger than the line width of the characteristic X-rays of heavier elements by an order of magnitude of from 1 to 2.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an X-ray analyzing element capable of affording an increase in intensity of diffracted X-rays and in peak to background ratio.

According to the present invention, in order to prepare a heretofore impossible Johansson type built up film analyzing element, a film is built up on the surface of a base, which has been worked beforehand in a stepped form.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described in more detail with reference to the attached drawings, in which:

FIG. 1 is a diagram explaining the principle of a stepped X-ray analyzing element of the present invention;

FIG. 2 is a profile of wave length versus intensity of primary characteristic X-rays of carbon from graphite; and

FIG. 3 is the construction of an X-ray analyzing element of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, on the Rowland circle **2** having a diameter **2R** being tangent to an analyzing element **1** having a radius of curvature **2R** at the center C_0 thereof, there is provided a step **1'** having a radius of curvature **2R**. The center of the step **1'** intersects the circumference of the Rowland circle **2** at a point C and the step **1'** is perpendicular to a line $\overline{OC}$, the point O being a point on the Rowland circle diametrically opposite to the point C_0, and the angle subtended at the point O by the arc $\widehat{CC_0}$ being ϕ. Suppose that the angle defined by an X-ray directed from a point S on the Rowland circle **2** to the point C and the step **1'** is θ, the angle defined by an X-ray incident upon a point C' on the step **1'** and the step **1'** is $\theta+\Delta\theta$, the angle defined by an X-ray incident upon the point C_0 and the analyzing element **1** is θ, and the angle defined by the lines $\overline{OC}$ and $\overline{OC'}$ is $\Delta\phi$, then the deviation $\Delta\theta$ of the angle at the point C' from the angle θ at the point C or C_0 is theoretically

$$\Delta\theta \simeq \frac{\Delta\phi \sin\phi|\cos\theta-(\Delta\phi)^2|^2}{\Delta\phi-\tan\phi-\tan\phi} \quad (1)$$

On the other hand, from the Bragg's condition, there is the following relation,

$$\Delta\theta=\frac{\Delta\lambda}{\Delta}\tan\theta \qquad (2)$$

between the deviation $\Delta\theta$, the wave length λ of an incident X-ray, and the spectral line width $\Delta\lambda$ thereof. Then, an example of the comparison of a maximum deviation $\Delta\theta$ max. (the deviation at an extremity of the step 1') in the cases of the Johann type and the Johansson type bases is, from Equations 1 and 2, as follows:

Radius of curvature R=100 mm.
ϕ=0.1 (length of base: 40 mm.)
$\Delta\phi=2.5\times10^{-2}$ rad. (width of step: 10 mm.)
$\left.\begin{array}{l}\Delta\theta \text{ max. (Johansson type)}=5.0\times10^{-4} \text{ rad.}\\ \Delta\theta \text{ max. (Johann type)}=1.6\times10^{-2} \text{ rad.}\end{array}\right\}$ (3)
$\Delta\theta n_{1/2}$ ($\Delta\theta$ corresponding to one half of the natural line width of wave length λ)$=6.0\times10^{-3}$ rad.

Consequently, it can be seen that the line width of the wave length to be employed is very narrow in the case of the stepped Johansson type base because the deviation $\Delta\theta$ from the Bragg angle is very small. Even when ϕ=0.2 rad. (length of base: 80 mm.), $\Delta\theta$ max. of the stepped base is 9.0×10^{-4} rad. and hence sufficiently narrower than the natural line width.

FIG. 2 shows a profile of the C–K X-ray spectrum emitted by graphite. As shown in FIG. 2, the integration range of the wave length obtained by employing a stepped base is sufficiently narrower than that obtained by employing a Johann type analyzing element. Therefore, as is evident from a comparison between the natural line widths and their integration ranges shown in FIG. 2, the peak to background ratio can be greatly improved by employing a stepped base. Moreover, since the deviation $\Delta\theta$ s sufficiently small even when ϕ=0.2 rad. in the stepped base as contrasted to the fact that the deviation has exceeded the $\Delta\theta$ corresponding to the natural line width even at ϕ=0.1 rad. in the Johann type analyzing element as stated above, a high diffraction intensity can be afforded by employing a large stepped Johansson type analyzing element.

FIG. 3 is a stepped Johannson type analyzing element of the present invention constructed by successively providing a plurality of steps such as the step 1' shown in FIG. 1 to a base along the circumference of the Rowland circle.

I claim:

1. An X-ray analyzing element comprising a base having a stepped surface existing along the circumference of a Rowland circle, the surface of each step having a radius of curvature equal to twice that of the Rowland circle and the center of each of curvature of said steps lying on a line passing through the point of intersection of the step and said Rowland circle and a point diametrically opposite to the point of contact of the step on said stepped surface which is tangent to said Rowland circle.

2. An X-ray analyzing element according to claim 1 in which a built up film is laid on said stepped surface of said base.

No references cited.

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S. C. SHEAR, Assistant Examiner