

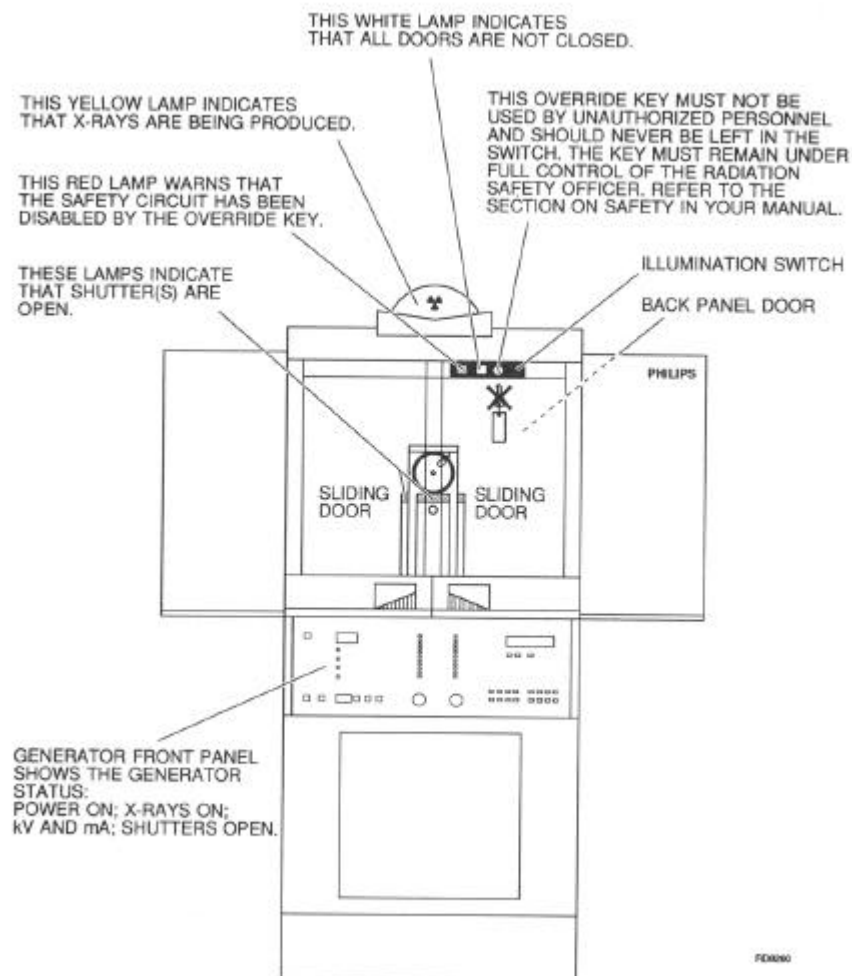
X-ray Diffraction (XRD)

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1. X-ray

X-ray (X-선) was discovered by Wilhelm Roentgen (로렌트젠) in 1895. It is a type of electromagnetic radiation with a wavelength of approximately 10^{-10} m (resolution of 10^{-1} cm). X-ray diffraction (XRD) is a technique used to determine the atomic structure of crystals. It is based on the principle of Bragg's Law, which states that the path difference between two rays is an integer multiple of the wavelength. The equation for Bragg's Law is $2d \sin \theta = n\lambda$.

2. X-ray



. 1 X -

X- 가 가 filament 가
가 eV 가

$$(1) E_k = eV = \frac{1}{2} m_e v^2$$

$$(2) v = \sqrt{\frac{2eV}{m_e}}$$

(e : , m : , v : , V :)

X- Target Material(1 % Cr, coulomb
Fe, Co, Ni, Cu, Mo, W)

X- X- (bremsstrahlung)

가 X- , X- X-
가 X-ray X-

가 coulomb
X-

가

E가 x

$$(3) E = eV = h\nu_{\max} = \frac{hc}{\lambda_{\min}}$$

$$(4) \lambda_{\min} = \frac{hc}{eV_{\max}}$$

$$(5) \lambda_{\min} = \frac{1.24}{V_{\max}} \text{ nm}$$

Duane - Hunt

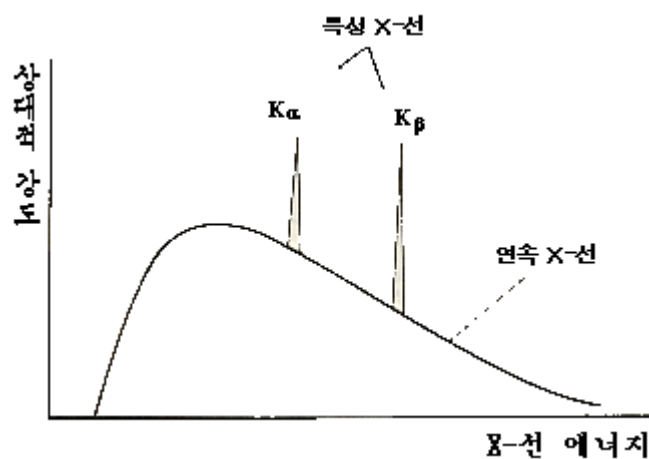
X-

X-

. 2

X-

X-



2.

X-

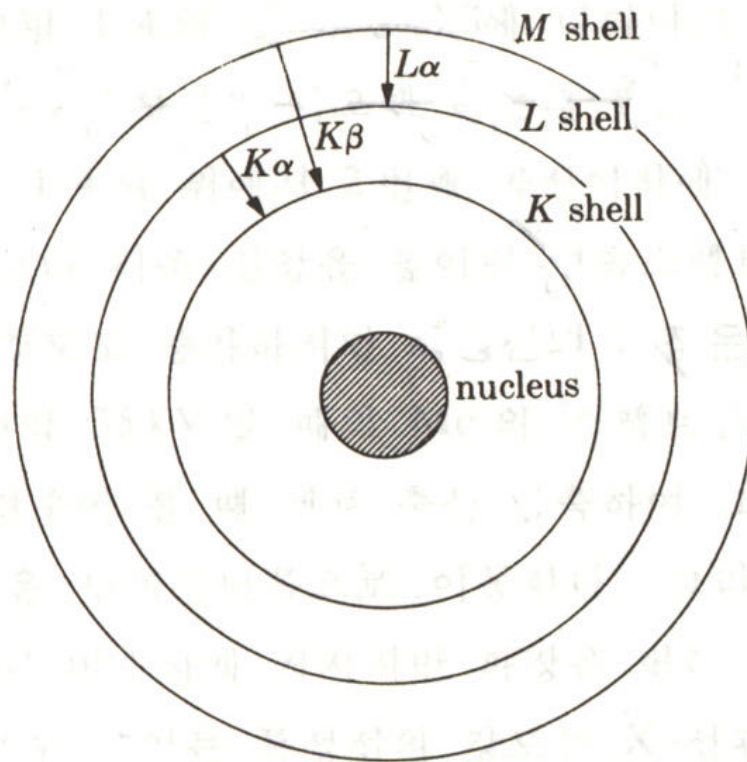
X-

X-

K, L, M

X-

3



. 3 X-

가 , 가 가 가 ,

가 K , L , M , X- K , X-

X- K α , M , K 가 L
M M , M , M , M , M , K α
1, K α 2 , K α 1 L , K α 2 L
2:1 K α 1, K α 2 X-

(6)

$$(6) I \propto I(V - V_k)^2$$

I , V 가 , V_k . n 2 .

3. X-

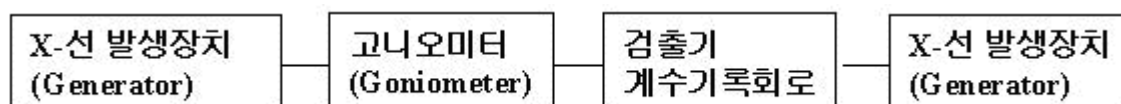
1. , 가

가 , , , , 가 , ,

2. , , thin film
가 .

3. 가 (JCPDS card)
4. d () 가
5. 가 50-200
- 6.
- 7.
- 8.
9. BaTiO₃, BaCo₃ TiO₂ 가
- 10.
11. 가 가
12. 가

4. X -



1) X - (GENERATOR)

(1) X -

- X- (Sealed type) : 가 1KW-3KW
- X- (Rotating anode) : 가 12KW tube

(2)

가 X- 35

2) (GONIOMETER) :

(1)

X-

. 4

X- X

X-

(line focus)

. (. 5)

(sollar slit)

(divergence
(receiving slit)

slit)

X-

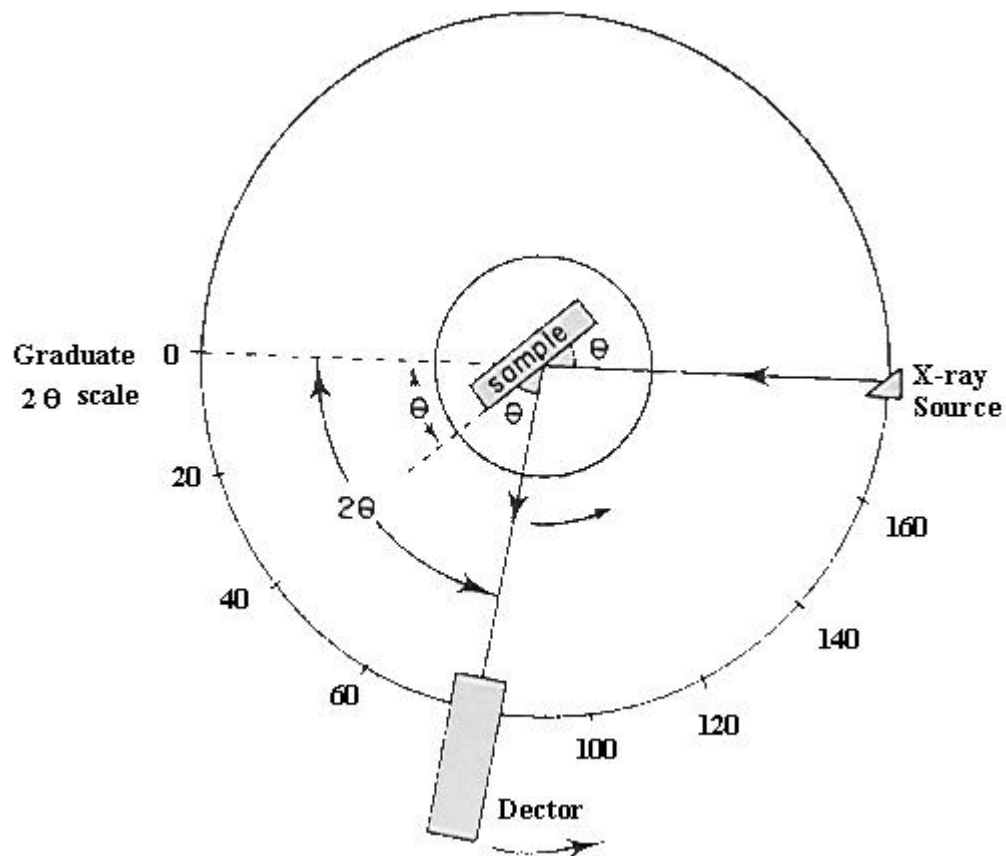
(scattering slit)

$1/6^\circ$; $1/4^\circ$; $1/2^\circ$; 1° ; 2° ; 4°

1°

0.15 mm가

0.3, 0.6 mm



. 4 Layout of X - ray diffractometer

F: X-

A :

P :

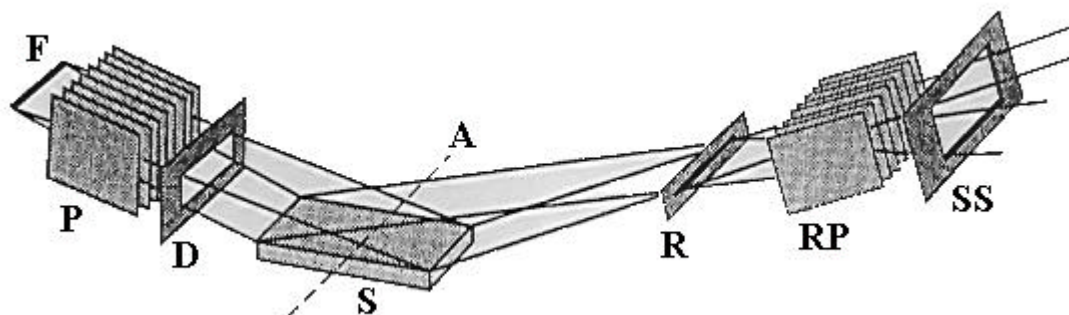
R :

D :

RP :

S :

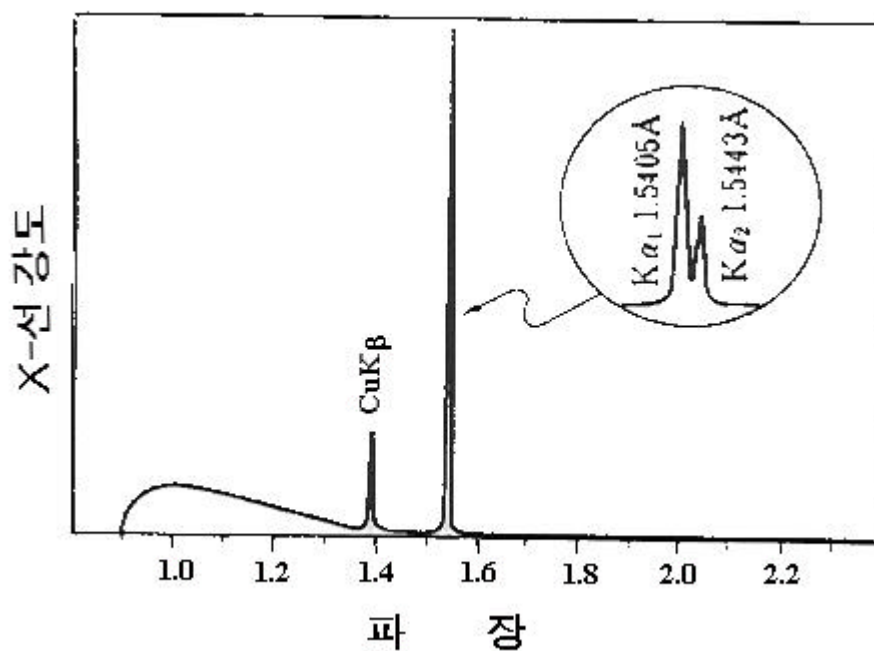
SS :



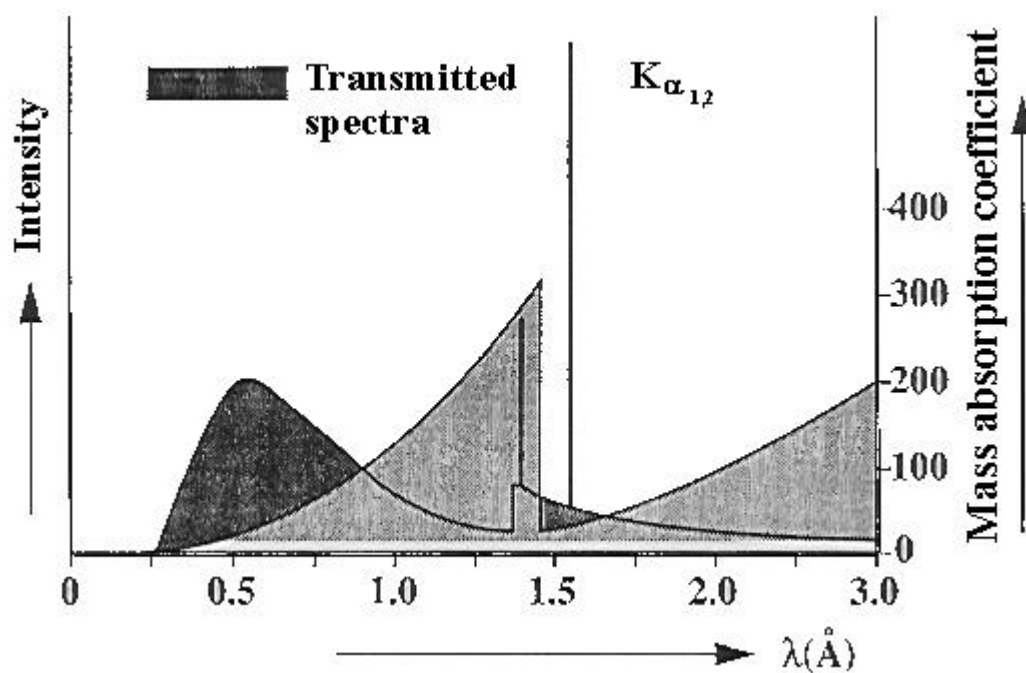
. 5

(2) (Filter)

X- target X- 가 Cu
 X- 6 3 peak, Ka1(1.54056), Ka2(1.5443
), Kb(1.392) 100 : 50 : 20
 X- Kb peak . (. 7)
 K target Ka Kb
 target 가 1-2 Cu target Ni , Mo
 Zr , Fe Mn , Cr V



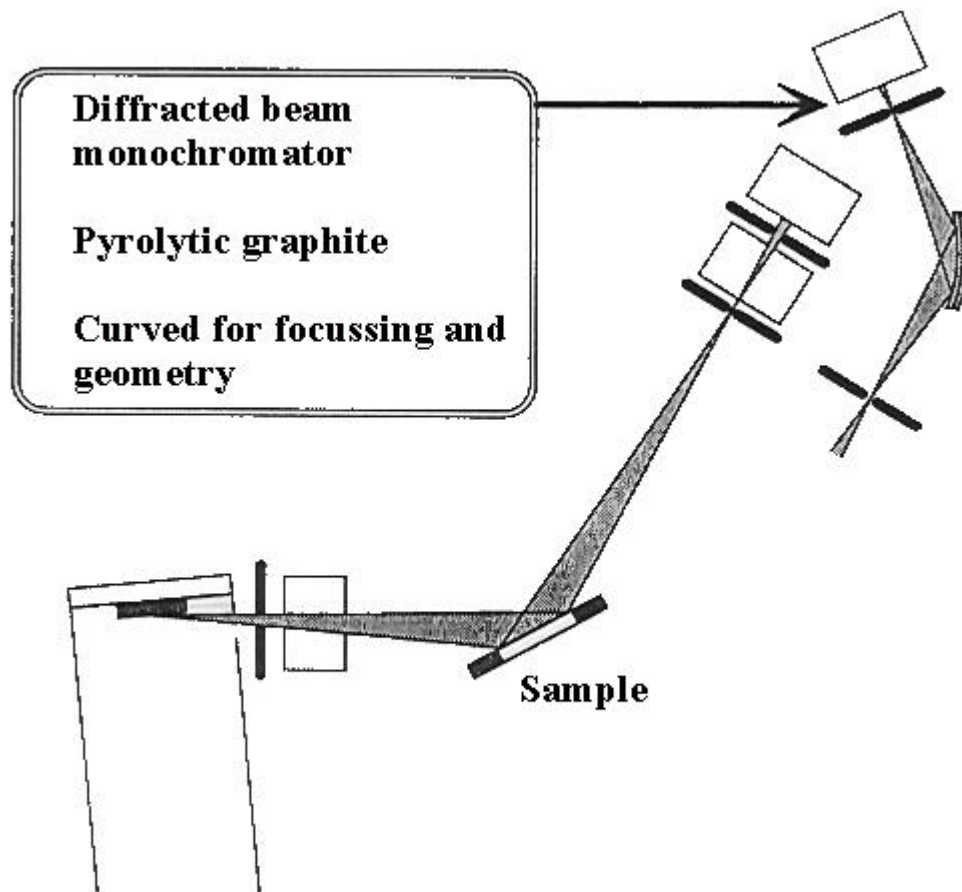
. 6 Cu X-



. 7 Primary spectrum and absorption by a b-filter.

(3) (Monochromator)

가 , monochromator Ka X- , (. 8) Kb 가 X-
 , background X- ,
 , Fe K X- ,
 CuKa background 0 가 FeKa, FeKb .
 Cu X- monochromator



. 8 The diffraction beam monochromator.

3) (Electronic circuit panel)

(1) : Xe, Kr, Ar
(proportional counter)

(2) X- (PHA)

5. X -

1)

(1)

(2)

(3) X -

(4)

: Cu
($K\alpha_1=1.5406$)

X-

X-

background가

. CuKa

Fe

Co

Cu

Fe

Co

가
가

X-

Fe

Co

Cu

Fe

Co



2)

(1)

가 10 - 30 mm 가 , 가

(2)

polishing

(3)

5 × 5 mm 가 40 mm
X- 가 plate 2
data 가 X-
가 data

3)

(1) (Scan axis)

2θ : 가 X-
 2θ , 2θ
 2θ : 2θ ()
 2θ (0.5 - 3 °) X- 2θ X-
 2θ : Rocking - curve , 2θ () 2θ

(2)

(Scan type)

(Continuous scan) :

가

(Step scan) :

가

것

(3) (Scan range)

JCPDS Card
($2\theta=5-140^\circ$) peak (2-3 $^\circ$) peak

Wide angle goniometer 가 $2\theta=3-145^\circ$

(4) (Scan speed)

0.25 $^\circ$ /5 $\frac{1}{2}$ min 4 $^\circ$ /5 $\frac{1}{2}$ min (8 $\frac{1}{2}$ min)
background

(5) (Sampling interval)

(Step width) 1 $^\circ$ 20 data가 0.05 $^\circ$ 0.05 $^\circ$

(6) (Power)

X- 4-5 가 가
가 Cu 30-50 kV가
background X-ray 40 kV, 40 mA
가 peak background

4) X- X-

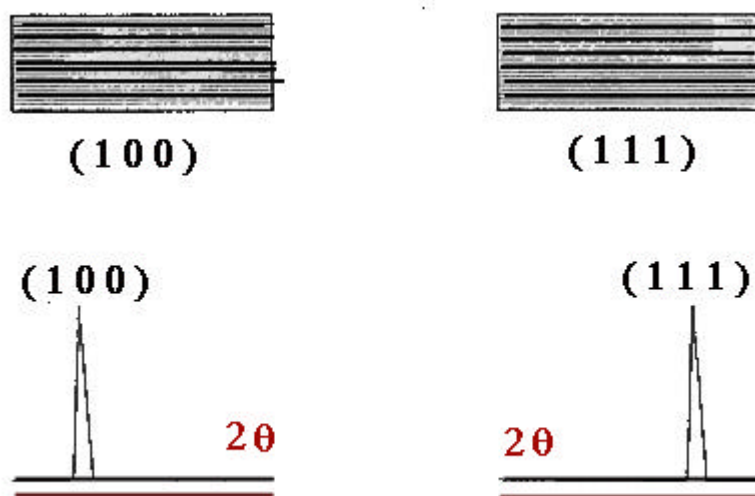
X- 가 X-
X- X-
(window)

가
X- 가
1 2 가
가
X- 1 2 X-
1
power가 X- X-
가 X- X-
X- , X-
가

(2)

Si wafer
11

가



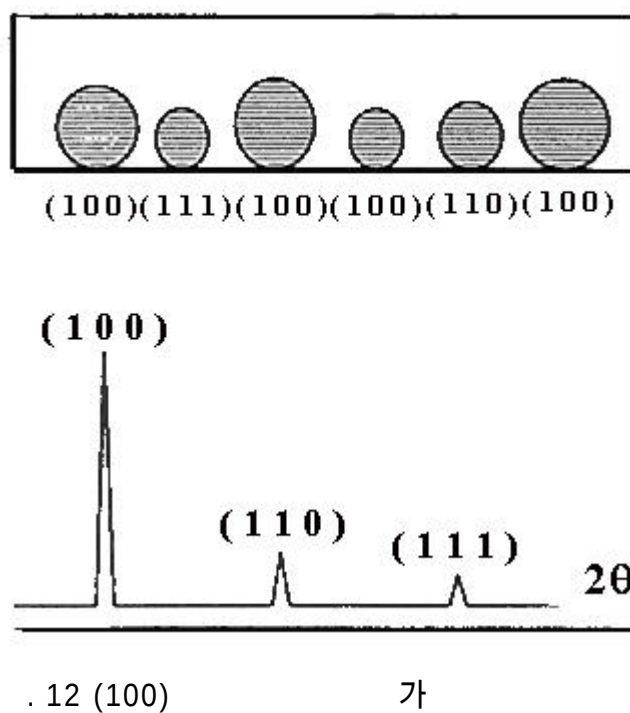
11

(3)

가

12 (100)

가

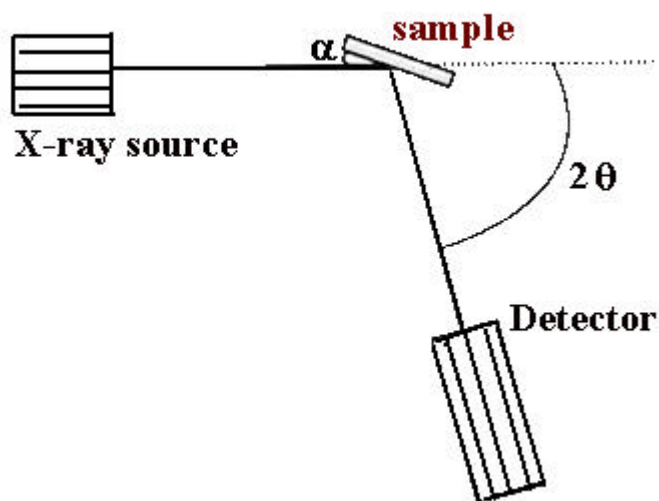


12 (100)

가

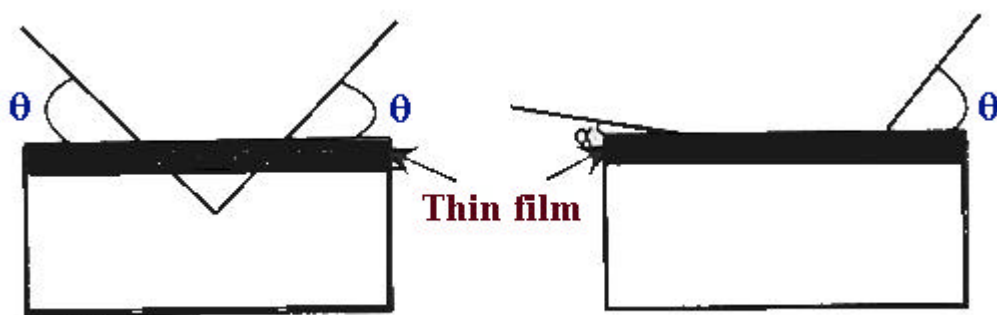
2) 2è

(Fixed - è scan)



. 13 2θ

. 13 X-
가 , 2θ
 $\alpha=20^\circ$; $2\theta=20^\circ - 60^\circ$
20° 60°
X-
. 14
peak

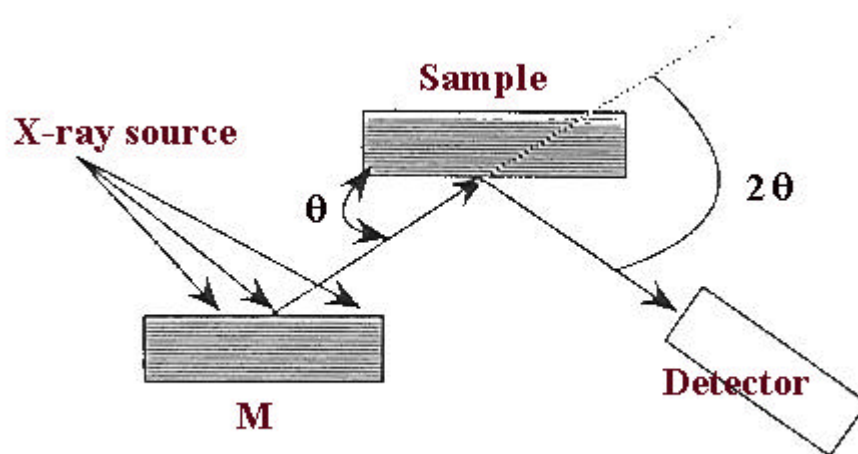


. 14

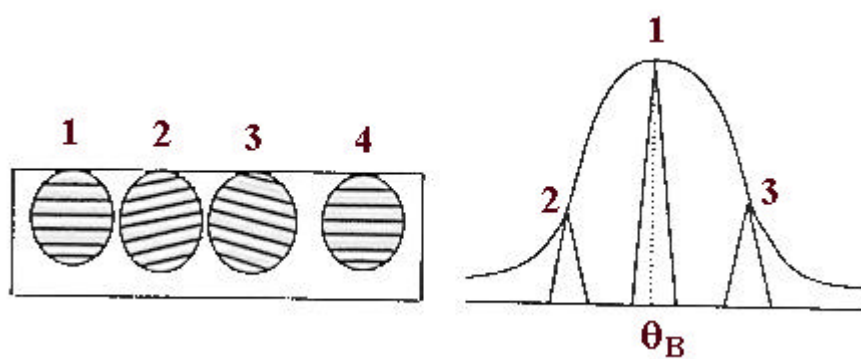
2θ

3) θ (Fixed - 2θ scan, Rocking - curve)

. 15 X- 2θ . 16
Rocking curve
M(. 15) X-
ray M X-
epitaxial
[Pole - figure](#)
Crystal
X-



. 15 è



. 16

가

è

4) È - È

è - 2è

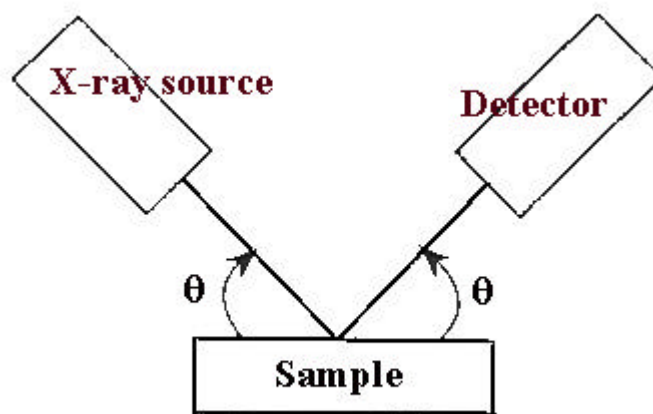
, . 17

X -

가

è - è

가



. 17 è - è