ON BASIC MEASUREMENT OF DIFFRACTION RING BY MEANS OF ELECTRON MICROSCOPE

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In analysis of the diffraction ring of Debye-Scherrer-Hull by means of the electron microscope, the usual method is that when a crystal having the diffraction ring belongs to the isometric system, a photograph is taken of that of pure gold-foil to determine the lattice point and lattice plane of the former in comparison with the latter.

The author has attempted to devise a graph which would enable him to obtain a reading on the lattice distance without the photographic process of the diffraction ring of gold-foil.

As the initial step of the attempt, the diffraction ring was photographed of gold-foil. Its degree of magnification was gradually changed by elevating the exciting current of the incident lens with the identical view from 60 mA to 110 mA at an interval of 5 mA. Table 1 gives the readings of the diameters of these diffraction rings.

TABLE 1
Actual Readings of the Diffraction Rings of Gold-foil

No.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	Lattice plane marks
Exciting current	60 mA	65	70	75	80	85	90	95	100	105	110 mA	
Ring diameters	mm											
	20.0	25.0	25.0	27.0	30.0	31.5	34.0	35.5	36.0	36.25	36.0	(555)
	23.0	29.0	29.5	32.0	34.5	36.5	39.0	40.5	41.5	42.0	41.0	
	32.5	—	41.0	44.5	49.0	52.5	55.5	57.0	58.5	59.0	59.0	(331)
	37.5	41.0										(221)
	39.0	—	48.5	53.0	57.0	61.0	64.5	66.5	68.5	69.0	69.0	(300)
						64.0	67.0	69.0	71.5	72.0	71.5	
	51.5	—	64.0	69.5	75.0	80.5	85.0	88.5	90.0	91.0	90.5	(211)
					77.0	82.5	87.0	90.0	93.0	93.5	93.0	
	60.0	65.0	71.5	77.5	85.0	90.5	96.0	99.0	102.0	102.5	101.5	
	65.0	71.5	76.0	82.5	90.0	96.5	103.0	105.0				(200)
	68.5	76.0	82.5	94.0	98.0	110.0	117.0	120.0	122.0	123.0		(111)
	76.0	86.5	—	105.0								(110)
	83.0	—	—									

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The above readings are represented graphically by Fig. 1.

In the graph the magnifications of the ring are given in terms of a straight line from 60 mA up to 85–90 mA and beyond this point the increase in the current is not paralleled by the magnifications. When the actual distances of the lattice planes d_1, d_2, d_3 etc. and those of the photograph l_1, l_2, l_3 etc. are arranged in a simple relation of $d_1 : d_2 : d_3 = l_1 : l_2 : l_3$, they appear in the linear relations as given on Fig. 2.

A comparison between the two gives a justification of Fig. 2, in which the distances of the lattice planes exactly correspond from 60 mA to 90 mA. This holds true of not only of the gold atoms, but also of any metal the crystal of which belongs to the isometric system. Therefore, when the readings on the right-hand side of Fig. 2 are changed to those of any particular crystal, the same graph works quite validly as the direction and proportional distance of the lines remain the same. A facsimile of Fig. 2, made out to an appropriate size, can be used for the determination of the lattice plane of any isometric crystal, together with distances between the lattice planes.

In order to test the workability of this supposition, readings have been taken

on several kinds of metals with the isometric crystal with the uniform result that has have proved the original supposition correct.

By way of illustration, the actual readings on the diffraction ring of cobalt are to be treated here. The author made an oblong slip of paper into a rule on which were entered the graded markings. This paper slide was made to run vertically and horizontally in parallel to the spindle of Fig. 2. By so doing, he obtained the position at which the markings of the slide matched those of Fig. 2, determining the corresponding lattice plane marks on Fig. 2. Following this, he was able to calculate the lattice distances of cobalt by means of the actual reading on the diameter of cobalt diffraction ring and that of gold diffraction ring photographed by the exciting current, with the distance of crystal lattice of the latter (4.07 Å) as an indicator.

TABLE 2
Calculations of Lattice Distances on Co Diffraction Ring

Ring diameters d	Lattice plane marks on Fig. 2	Ring diameters of gold corresponding to 80 mA exciting current	Distances of crystal lattice (crystal lattice of gold $a'=4.07$) $a (=a' \times \frac{d}{d'})$
75.7 mm	(111)	98.0 mm	3.14Å
69.5	(200)	90.0	3.14
51.5	(300) (221)	57.0	3.75
31.0	(600)	34.5	3.49
27.0	(555)	30.0	3.30
			Average 3.36

Thus, the resulting crystal lattice of cobalt is 3.36 Å as is given in the extreme right side column of the Table 2 above.

The present study furnishes the following findings.

1. With use of the electron microscope equipped with Nihon University School of Dentistry (Type HU 10 manufactured by Hitachi Electric Mfg. Co., Japan), the analysis of the diffraction ring of isometric crystals can be conducted at the exciting current of 60 mA to 90 mA, without the usual process of the simultaneous photography of gold diffraction ring.

2. The present method of measurement is confined to crystals of the isometric system. However, a further study is being contemplated in regard to other crystals such as hexagonal system and tetragonal system.