HKLforQuartz User Guide

Determination of Miller indices (hkl) and Miller-Bravais indices (hkil) for various quartz cuts/faces

IntelliEtch Developers

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Input arguments				Output						
alpha 1	-49			h	0 i -2		k 2			
alpha2	90	trans	form->	i			1	I -3		
Information	n	h	k		I		phiX		phiY	phiZ
Normalized by max:		0.0000	0.6843		1.0000	1	90.00	000	49.0000	139.000
Normalized by min:		0.0000	1.0000	1.	1.4613	1	90.00	000	49.0000	139.000
Approx. integers:		0.0000	2.0000	1.	2.9227	1	90.00	000	49.0000	139.000
Miller indices:		0.0000	2.0000	1.	-3.0000	1	90.0	000	49.7392	139.739

Usage:

The tool **HKLforQuartz** can be used to determine the Miller indices (hkl) and Miller-Bravais indices (hkil) [i=-(h+k)] for a quartz cut defined by two angles, θ_1 and θ_2 .



Background:

According to different cut angles to the quartz bars, there are different quartz plates, e.g. AT-, BT-, CT-, DT-, NT-, GT-cuts. Different quartz cuts, indicated by a set of angles, have different available elastic, piezoelectric and dielectric properties, which are the basic parameters for designing a quartz crystal device. The most often used quartz cuts are shown here:



•Z-cut: 90° from Z axis

•AT-cut: Rotate 35.256° about the X axis towards the negative Y axis •BT-cut: Rotate 49° about the X axis towards the positive Y axis •CT-cut: Rotate 38° about the X axis towards the negative Y axis •DT-cut: Rotate 52° about the X axis towards the positive Y axis •NT(50,5)-cut: Rotate 50° about the Y axis towards the negative X axis, then rotate 5° about the Z axis towards the negative X axis.

•NT(60,8.5)-cut: Rotate 60° about the Y axis towards the negative X axis, then rotate 8.5° about the Z axis towards the negative X axis.

•etc...



Definition of angles θ and (θ_1, θ_2) used to describe quartz cuts/faces





Table 1: Miller indices and Miller-Bravais indices for typical quartz cuts/faces

Cut	Face	θ [deg]	(θ_1, θ_2) [deg]	(h k l)	(h k i l)	Angle to X-, Y- and Z- axis [deg]
AT	-	35.4167 - -	(35.4167,90) (35.4167,210) (35.4167,330)	0 10 9 -10 0 9 10 -10 9	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	90.000035.316754.6833134.9630114.078354.683345.0370114.078354.6833
BT	-	-49 - -	(-49, 90) (-49,210) (-49,330)	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	90.0000 49.7392 139.7392 124.0340 108.8525 139.7392 55.9660 108.8525 139.7392
СТ	z or R	38 - -	(38,90) (38,210) (38,330)	$\begin{array}{ccccc} 0 & 1 & 1 \\ -1 & 0 & 1 \\ 1 & -1 & 1 \end{array}$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	90.0000 38.2098 51.7902 132.8812 113.1336 51.7902 47.1188 113.1336 51.7902
-	r	- - -	(38, -90) (38, -210) (38, -330)	$\begin{array}{cccccccc} 0 & -1 & 1 \\ -1 & 1 & 1 \\ 1 & 0 & 1 \end{array}$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	90.0000 141.7902 51.7902 132.8812 66.8664 51.7902 47.1188 66.8664 51.7902
DT	-	-52 - -	(-52, 90) (-52,210) (-52,330)	0 8 -13 -8 0 -13 8 -8 -13	0 8 -8 -13 -8 0 8 -13 8 -8 0 -13	90.0000 51.9838 141.9838 122.2335 107.9352 141.9838 57.7665 107.9352 141.9838
ST	-	42.75	(42.75, 90) (42.75, 210) (42.75, 330)	$\begin{array}{ccccc} 0 & 6 & 7 \\ -6 & 0 & 7 \\ 6 & -6 & 7 \end{array}$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	90.000042.564347.4357129.6312111.608347.435750.3688111.608347.4357
NT(50,5)	-	-	(50,5)	92 -39 121	92 -39 -53 121	50.1645 86.7737 40.0198
NT(60,8.5)	-	-	(60,8.5)	27 -10 52	27 -10 -17 52	60.3537 85.7539 30.0102



Definition of (θ_1, θ_2)





Table 2: Miller indices and Miller-Bravais indices for typical quartz cuts/faces

Cut	Face	Sub-face	(θ_1, θ_2) [deg]	(h k l)	(h k i l)	Angle to X-, Y- and Z- axis [deg]
X	a	a1+ a1- a2+ a2- a3+ a3-	(0, 0)(0, 180)(0, 120)(0, 300)(0, 240)(0, 60)	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
Y	m	m1+ m1- m2+ m2- m3+ m3-	(0, 90) (0, 270) (0, 30) (0, 210) (0, 330) (0, 150)	$\begin{array}{ccccccc} 0 & 1 & 0 \\ 0 & -1 & 0 \\ 1 & 0 & 0 \\ -1 & 0 & 0 \\ 1 & -1 & 0 \\ -1 & 1 & 0 \end{array}$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	90.00000.000090.000090.0000180.000090.000030.000060.000090.0000150.0000120.000090.000030.0000120.000090.0000150.000060.000090.0000
Z	с	c+ c-	(90,0) (270,0)	0 0 1 0 0 -1	0 0 0 1 0 0 0 -1	90.000090.00000.000090.000090.0000180.0000
-	S	s1 s1' s2 s2' s3 s3'	(155.5587, 0) $(24.4413, 0)$ $(155.5587, 120)$ $(24.4413, 120)$ $(24.4413, 240)$ $(155.5587, 240)$	$\begin{array}{ccccccc} -2 & 1 & 1 \\ 2 & -1 & 1 \\ 1 & -2 & 1 \\ -1 & 2 & 1 \\ 1 & 1 & 1 \\ -1 & -1 & 1 \end{array}$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	155.558790.000065.558724.441390.000065.558762.9227142.037865.5587117.077337.962265.558762.922737.962265.5587117.0773142.037865.5587
-	X	x1 x1' x2 x2' x3 x3'	(171.958, 21.054) (8.042, 21.054) (171.958, 141.054) (8.042, 141.054) (8.042, 261.054) (171.958, 261.054)	$\begin{array}{ccccccc} -6 & 1 & 1 \\ 6 & -1 & 1 \\ 5 & -6 & 1 \\ -5 & 6 & 1 \\ -1 & -5 & 1 \\ 1 & 5 & 1 \end{array}$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	157.5280110.834781.952622.472069.165381.952639.6411128.493781.9526140.358951.506381.952698.8594167.987381.952681.140612.012781.9526