

JpGU 2016 SMP43-P05:

Inconsistency between SEM image and Crystal orientation data obtained by SEM-EBSD systems

*Akira Miyake¹, Aki Takigawa^{1,3}, Yohei Igami¹, Shugo Ohi², Ryuta Nakamura¹, Akira Tsuchiyama¹

1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University,

2.Faculty of education, Shiga university, 3.The Hakubi Center for Advanced Research, Kyoto University

Digest version

2016/5/25

Last update 2016/6/18

Inconsistency between orientations of the EBSP and SEM image

We confirmed the **systematic inconsistency between SEM images and crystal orientations** obtained by HKL channel 5 (Flamenco, Oxford Instruments) in our SEM-EBSD systems. We show procedures to confirm the orientation relation between the EBSP and SEM images in SEM-EBSD systems. For many cases, the orientations shown by HKL channel 5 were just consistent with the SEM images rotated by 180 degree around the sample normal direction.

This inconsistency results in the **incorrect crystal orientations** and is especially critical for the determination of the three dimensional crystal orientations and of crystal faces of the sample crystals

Our systems used in the test experiments

SEM	EBSD	consistency
1. JEOL, JSM-7001F	Oxford Instruments, Flamenco	inconsistent (180° rotation required)
2. FEI, Quanta 200i 3DS	Oxford Instruments, Flamenco	inconsistent (180° rotation required)
3. FEI, Helios G3	Oxford Instruments, Flamenco	inconsistent (180° rotation required)
4. HITACHI, S-3000H	Oxford Instruments, Flamenco	consistent

Previous reports about the inconsistency

- ✓ El-Dasher et al. (2009, 2012, ...) reported the possible inconsistencies between SEM images and crystal orientations obtained by SEM-EBSD systems.
- ✓ Suzuki (2013) reported that the angle between SEM image and the orientation obtained by EBSD was 180 degree.
- ✓ Kilian et al. (2016) said “Recent benchmarks and comparison of reference data revealed that for various EBSD setups around the world, the orientation data defaults to the wrong absolute orientation. The absolute orientation is not correctly derived - it commonly suffer a 180 degree rotation around the normal of the sample surface” at EGU2016-8221.

Systems are tested by Kilian et al. (2016)

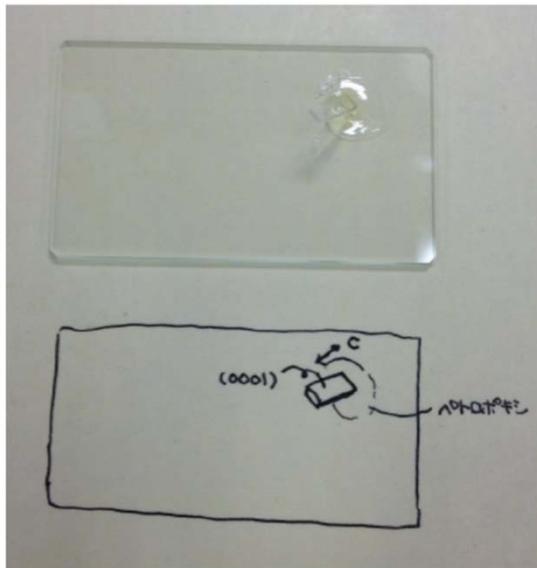
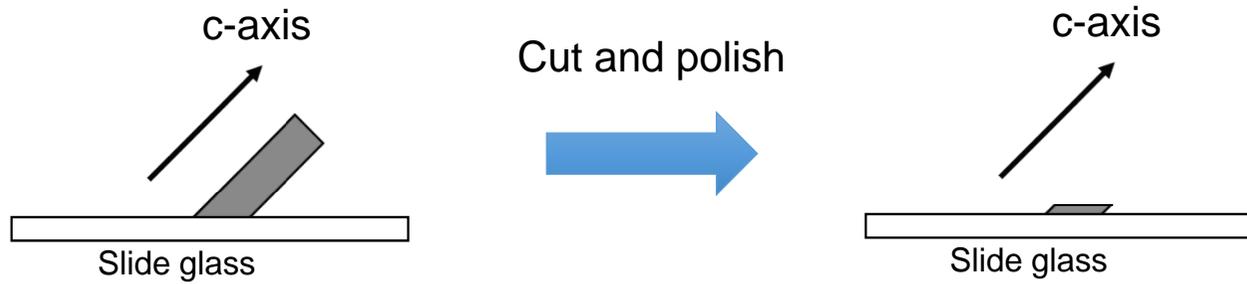
SEM	Oxford Instrument Acquisition software
1. Tescan (Vega)	Flamenco
2. Zeiss (Cross Beam 1540Esb)	Flamenco
	Fast Acquisition software
3. FEI (Helios 600i)	AZtec
4. Zeiss (Merlin)	AZTec

Procedure to confirm the inconsistency

1. Sample preparation
 - a. Prepare the sample with the known crystal orientation
(Trigonal or hexagonal crystals are recommended (e.g., quartz and corundum))
 - b. Glued the sample with c-axis towards north-east onto the slide glass.
 - c. Grinding, chemical polishing and coating
2. Put the sample to SEM with c-axis towards north-east (**NE**) on SEM image.
3. Get the EBSP and index the crystal orientation.
4. Plot the crystallographic direction from the obtained Euler angle on Wulff net (upper hemisphere plot)

Is the c-axis obtained by EBSD plotted toward NE?

Test sample: Corundum



Thanks to Masaki TAKAYA

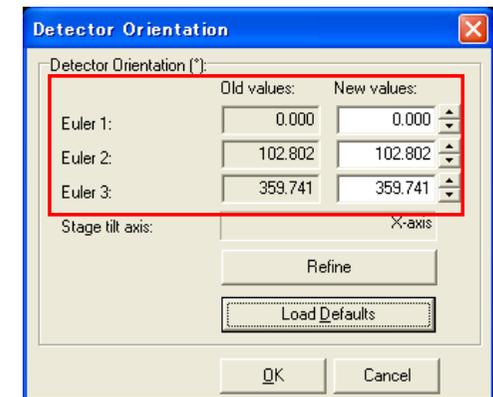
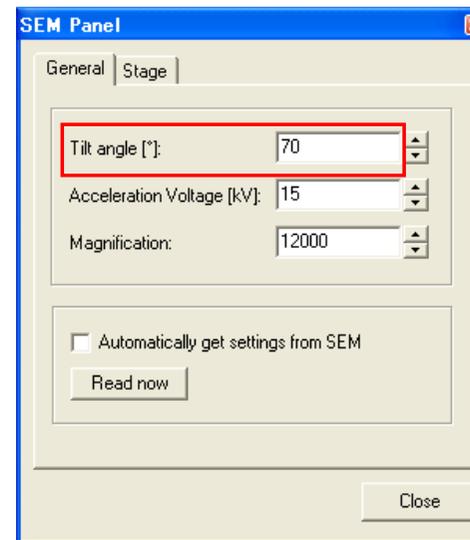
Parameters used in Flamenco

We inputted the setting parameters that Oxford instruments recommend to use

Sample tilt (degree) : +70 in all SEM

Detector orientation (degree) :

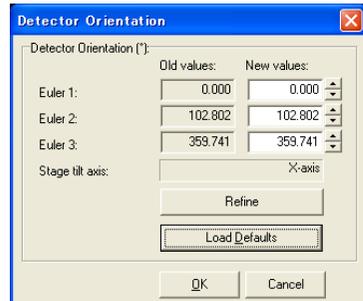
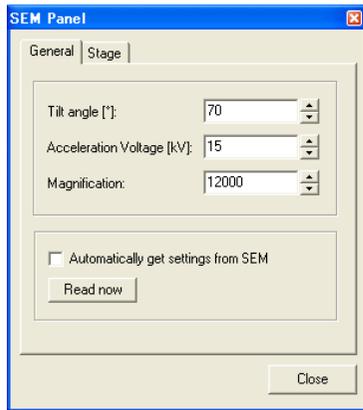
JSM-7001F:	0,	90,	0
Quanta 200i 3D:	0,	102,	0
Helios G3:	0,	102,	0
S-3000H:	0,	90,	0



Quanta 200i 3D/Helios G3

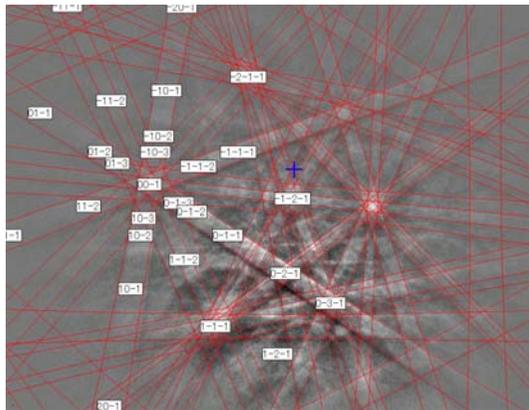
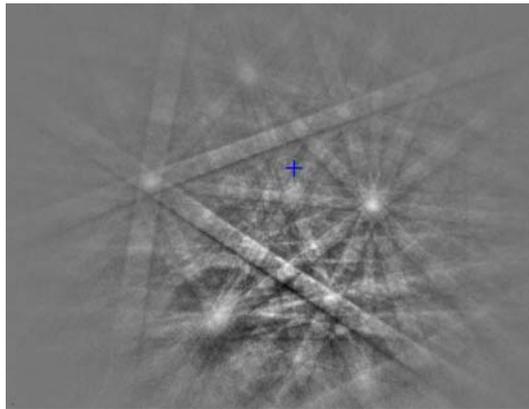
EBSP and the crystal orientation indexed with the setting parameters proposed by Oxford instruments

Setting parameter

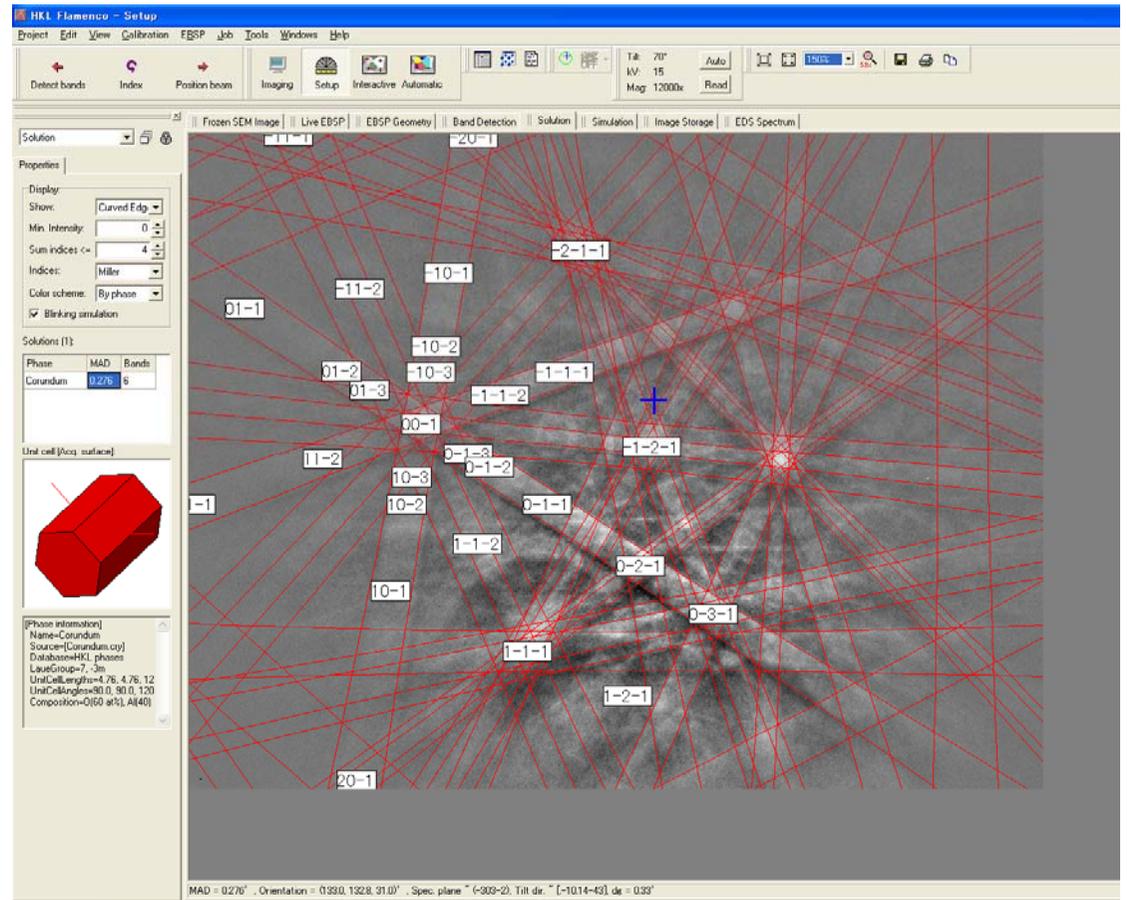


Sample tilt: 70
 Detector orientation:
 0, 102, 0

EBSP

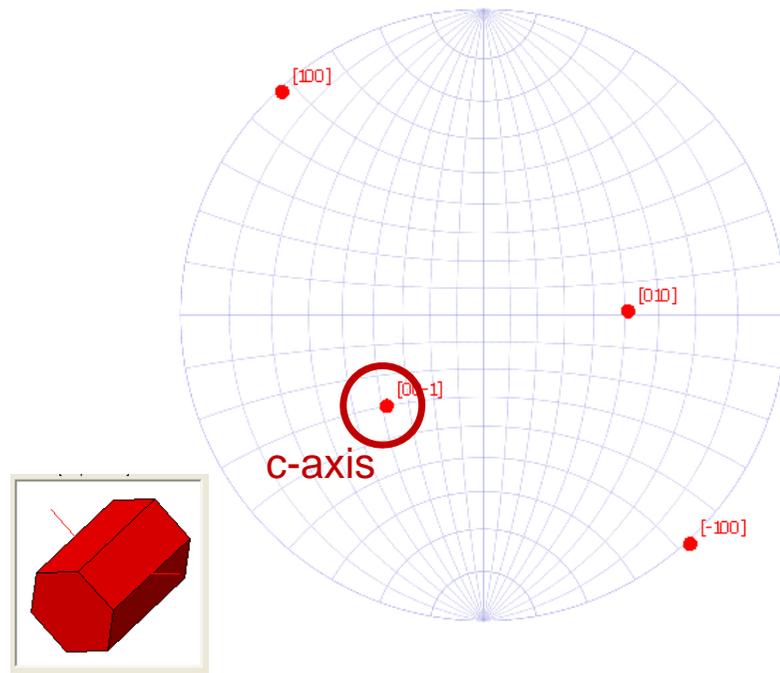


Indexed orientation

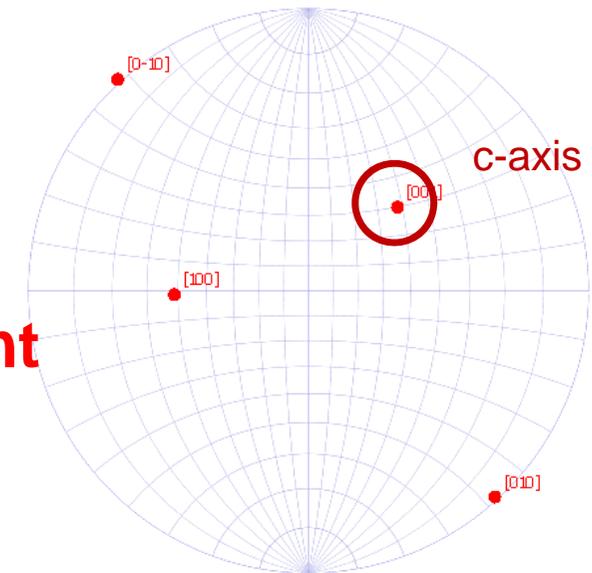


Plot on the Wulff net - upper hemisphere plot -

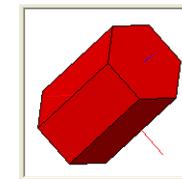
Obtained orientation by EBSD
(c-axis plots toward **SW**)



Actual orientation (SEM image)
(c-axis plots toward **NE**)



inconsistent



The orientation obtained by EBSD was inconsistent with the SEM image. Rotation of either SEM image or EBSP by 180 degree around the sample normal direction is required to achieve consistency.

Results

SEM	EBSD	Detector orientation (degree)	c-axis (SEM image= NE)
1. JEOL, JSM-7001F	Flamenco	0, 90, 0	SW
2. FEI, Quanta 200i 3DS	Flamenco	0, 102, 0	SW
3. FEI, Helios G3	Flamenco	0, 102, 0	SW
4. HITACHI, S-3000H	Flamenco	0, 90, 0	NE

Sample tilt (degree) : 70 in all SEM

The orientations obtained by EBSD in JSM-7001F, Quanta 200i 3DS and Helios G3 were inconsistent with SEM images and consistent with the SEM image **rotated by 180 degree around the sample normal direction.**

※We do not know the other system and software, although, maybe, we think Aztec is same as Flamenco.

Official statements by Oxford instruments

It is important to realize that the EBSD orientation calibrations in Flamenco and AZtec does not relate to the orientation of the scanned image

IF you want to change the orientation of the used reference frame then it can be done either by:

- Rotating data after acquisition by a system specific angle (recommended option)
Either 0 or 90 or 180 or 270 deg around surface normal
- Using a system specific scan rotation angle on SEM to bring SEM image orientation to coincide with reference coordinate system for EBSD data (CS1)
- Change the tilt and detector orientation values to rotate the CS1 coordinate system to coincide with the orientation of the SEM image (this is easier to do in Flamenco than in AZtec) and is not a good idea as it causes other problems (EDS, LAM, ...)