

Orientation and Phase Mapping with Transmission Electron Microscopes

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CNRS / Grenoble - INP

ACOM/TEM : Automated Crystal Orientation Mapping on TEM

- 'DigiStar' : Precession tool for TEM

= ASTAR



Nanocrystalline Al



TRIP steel with retained austenite







1) ACOM/TEM :

Template matching

Pattern acquisition and template generation



Combining orientation/phase identification with Electron Precession





ACOM/TEM : Automated Crystal Orientation Mapping







ACOM/TEM : Automated Crystal Orientation Mapping





Kikuchi pattern



Orientation Ω



Bragg Spot pattern



Orientation $\Omega + \Omega' (= \Omega + 0.1^{\circ})$



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ACOM/TEM : Orientation Indexing





ACOM/TEM : Crystallographic orientation identification Cris



ACOM/TEM : Reliability





Deconvolution of superimposed Diffraction patterns



ACOM/TEM : Phase identification and reliability



Austenite : Index $I_2 = 389$



ACOM/TEM : four steps





TEMdpa : Diffraction Pattern Acquisition





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TEMdpa : Virtual Bright Field on-line construction





TEMdpa : Virtual Bright Field on-line construction





Bright field image

Grenoble

Aluminium (mean grain size 200nm)



Orientation map

Virtual bright field image



DiffGen : Template generator





Structure generator (lattice, cell, structure factor)



DiffGen : Template generator





INDEX : pattern identification software

ACOM : some examples of orientation maps

Deformed Cu (coll. N. Llorca – Univ. Barcelona, Spain)

Correlation Index

Orientation reliability

Phase Reliability

Orientations

Grenoble

Fe 1.67% C (HT 10 min @ 1100℃, A. Stormvinter - KTH)

Martensite

Austenite

Grain size and Texture in 80 nm copper lines

500x100 steps (6.5 nm each) , Spot size 25 nm Scanning time : 19 min (44 fps)

Grenoble

Side view

300x100 steps (6.5 nm each), spot size 15 nm Scanning time : 12 min (44 fps)

SIDE VIEW (orientation and index superimposed map) The two scans were performed with different settings They demonstrated the reproducibility of the identification CROSS VIEW (orientation map)

Grain size of the order of 30 nm may be identify despite the use of a conventional LaB6 equipped Jeol 3010 TEM (spot size 25 nm). A fiber texture was detected within the channel.

250x100 steps (13 nm each) LaB6 equipped Jeol 3010 TEM (spot size 25 nm) Scanning time : 10 min (44 fps)

Credits: - Stefan BRANDSTETTER, SIMaP - Grenoble INP

ACOM/TEM combined to a FEG-TEM

JEOL 2010F *Texas Material Institute UT, Austin*

180 nm Cu lines

Pt nanocrystals

Virtual bright field

Orientation map

Correlation Index map

1) ACOM/TEM :

Template matching

Pattern acquisition and template generation

2) ASTAR :

Combining orientation/phase identification with Electron Precession

Precession Electron Diffraction patterns (R. Vincent, P.A. Midgley, Ultramicroscopy 53 (1994) 271.)

Precession Electron Diffraction patterns

Mayenite crystal ($Ca_{12}AI_{14}O_{33}$) : space group I-43d

Without precession

ACOM + Precession: Solving 180° orientation ambiguities

ACOM + Precession: Solving 180° orientation ambiguities

Practice ASTAR ('HRCOPM')

1) TEM practice (acquisition)

Grenoble INP

2) PC practice (indexing and viewing)

	Day 1 (Wednesday)		Day 2 (Thirsday)		Day 3 (Friday)	
	16 :00	17:30	16:30	18:00	13 :30	15:00
Groupe 1	TEM Room 0'503			PC practice Room 1'428		
Groupe 2	PC practice Room 1'428	TEM Room 0'503				
Groupe 3	PC practice Room 1'428		TEM Room 0'503			
Groupe 4		PC practice Room 1'428			TEM Room 0'503	
Groupe 5		PC practice Room 1'428				TEM Room 0'503

Indexing Fourier transform of High resolution TEM images

DiffGen : Template generator

ACOM : some examples of orientation maps

Orientation maps

ACOM/TEM : Automated Crystal Orientation Mapping

Fe 1.67% C (HT 10 min @ 1100°C, A. Stormvinter - KTH)

NanoMEGAS Advanced Tools for electron diffraction

Same area with (Y) and without (I) precession

TRIP steel (ferrite + austenite) ; Philips CM120 @ 100hz (6 min),

