Small Angle Scattering - Introduction

Why scattering at small angles?

Angle & size related thru Braggs' law:

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10 Å (0.001 micron)	8.84°	0.628 $Å^{-1}$
50 Å	1.77°	
100 Å (0.01 micron)	0.88°	0.0628 $Å^{-1}$
300 Å	0.29°	
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Small-angle scattering --> structure of BIG things

Small Angle Scattering - examples

WAXS and SAXS study of (m)TMXDI-PDMS siloxane-urethaneureas

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Hard segments --> regions with crystal-like order

Soft segments --> amorphous siloxane chains

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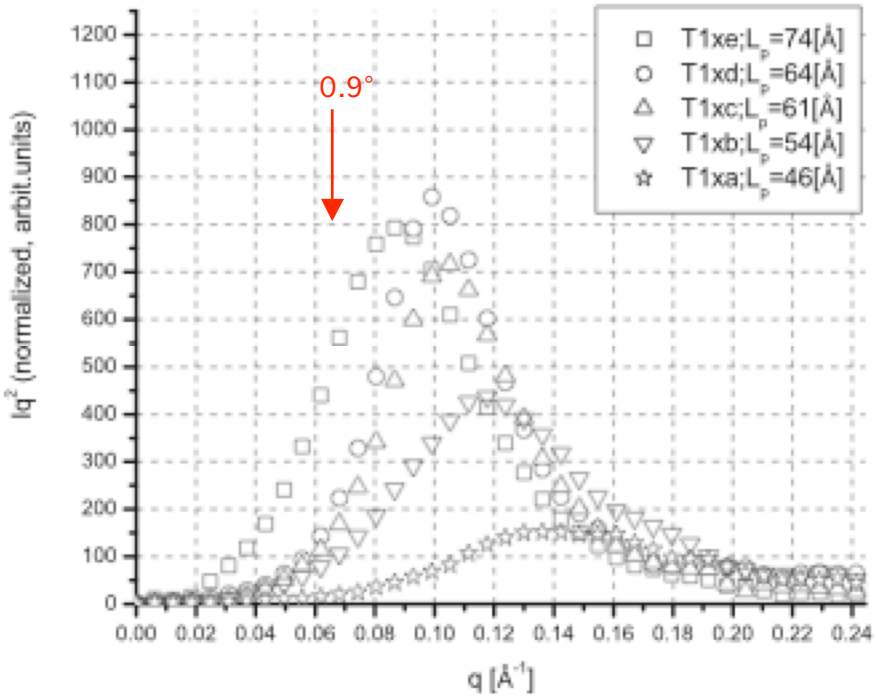
WAXS and SAXS study of (m)TMXDI-PDMS siloxane-urethaneureas

Saxs scattering curves for various NCO/OH ratios (a = 1.5/1; e = 4.5/1):

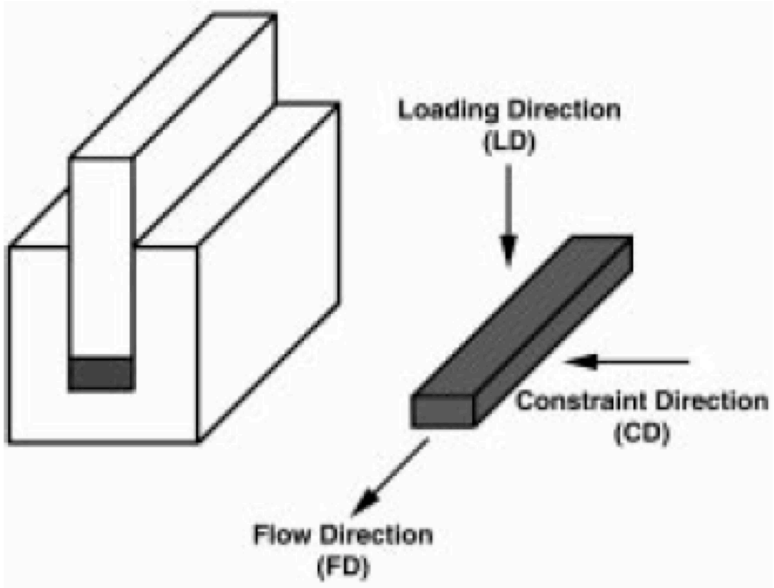
Size of the hard segment "crystalline" regions changes



Small Angle Scattering - examples

Microstructure orientation and nanoporous gas transport in semicrystalline block copolymer membranes

Polymer sheets of semicrystalline ethylene (E)/ethylene–propylene (EP) diblock E/EP and triblock E/EP/E copolymers made by channel die proessing



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Microstructure orientation and nanoporous gas transport in semicrystalline block copolymer membranes

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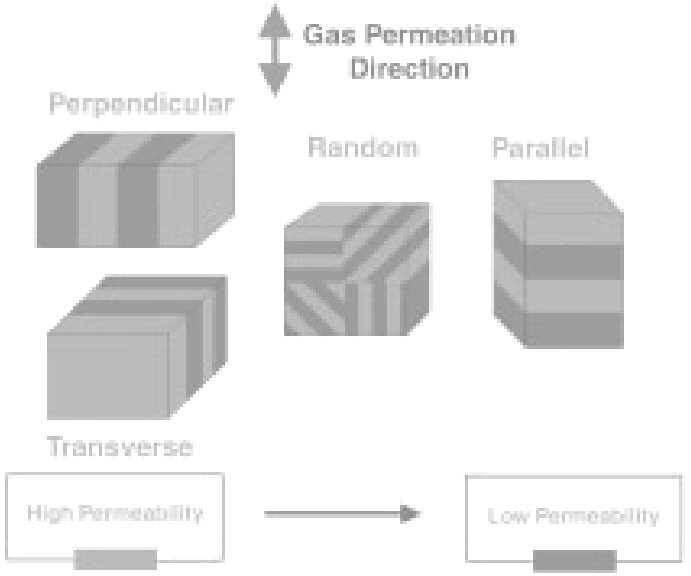
Sheets are stacked into several types of blocks w/ different gas transport props.



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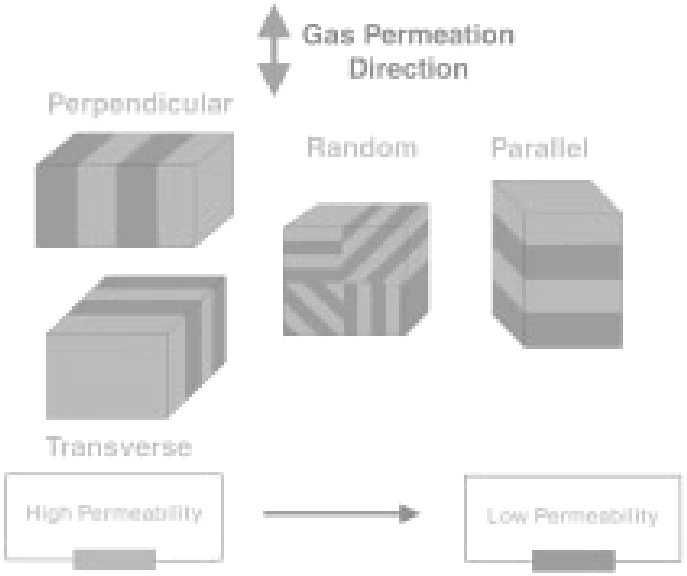
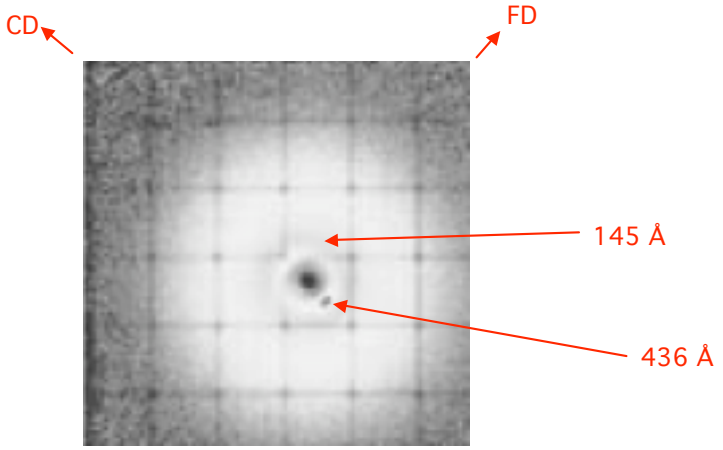
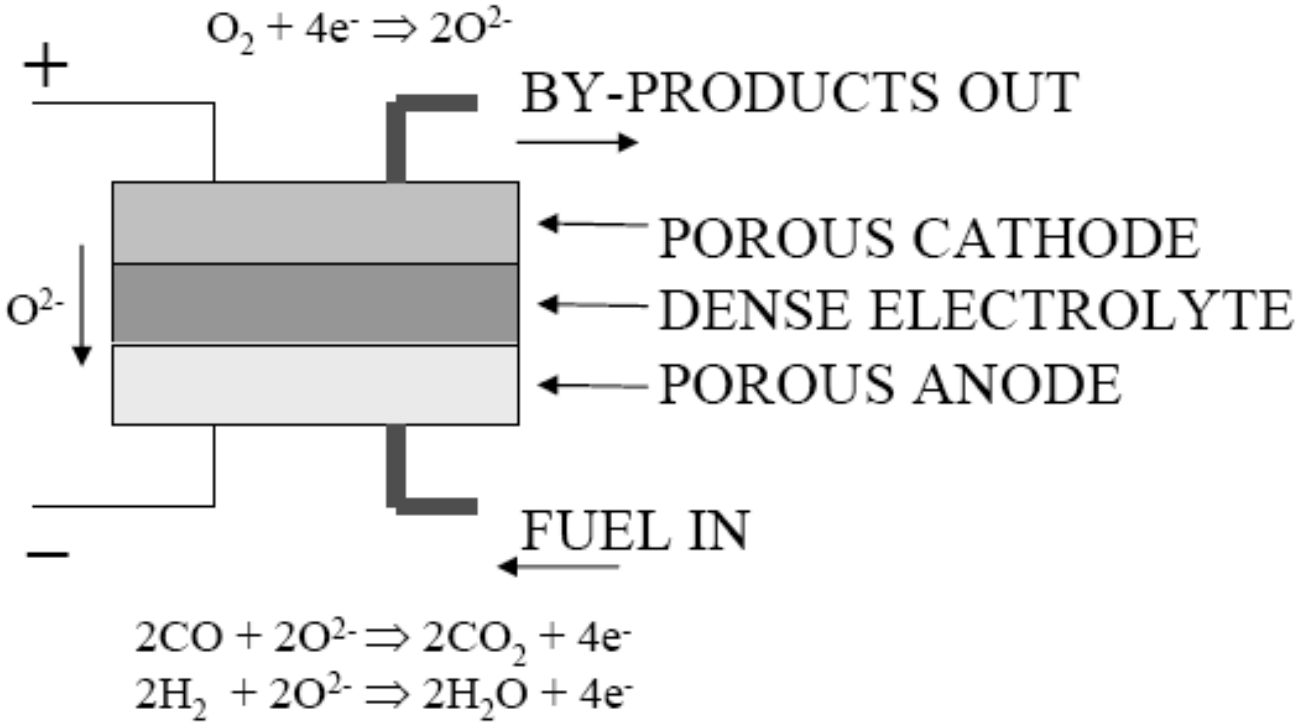




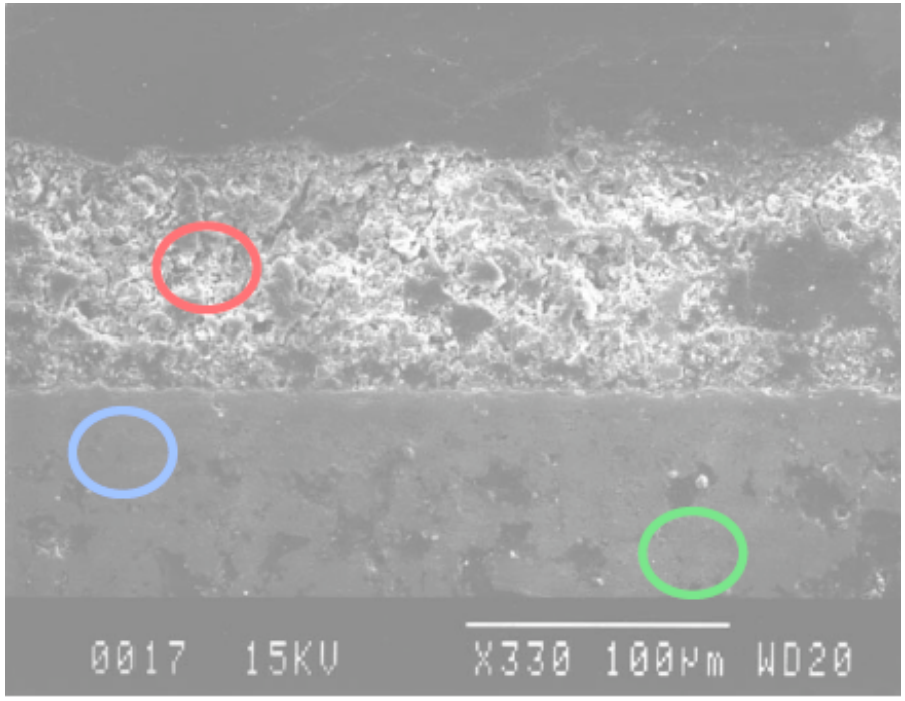
saxs image for perpendicular texture type

Small Angle Scattering - examples

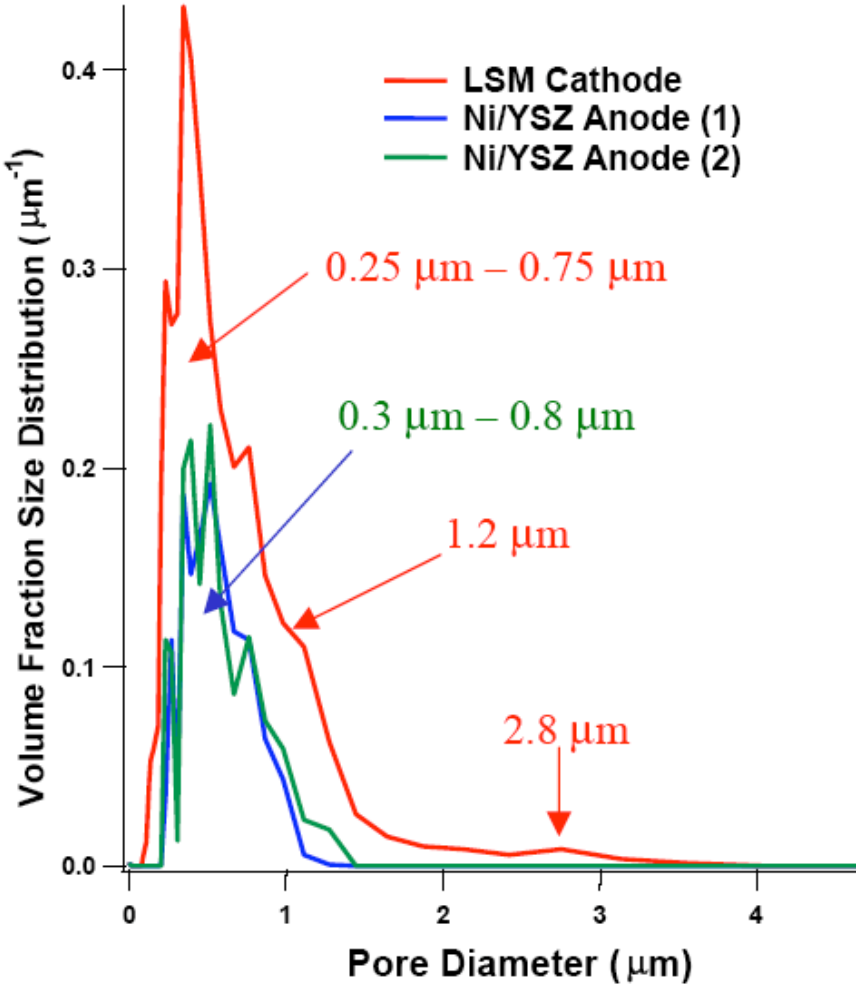
Nanometer to Micrometer Void Microstructure Characterization of SOFC Layers and Interfaces by Small Angle Scattering (SAXS) and Computed X-ray Microtomography(XMT)



Preliminary Void Size Distributions obtained from Maximum Entropy Analysis of SAXS Data:



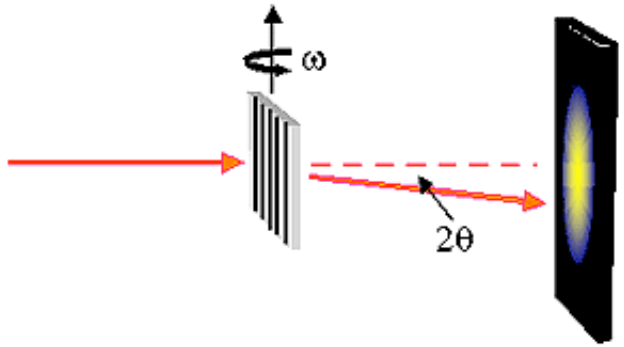
SEM micrograph near interfaces.



Small Angle Scattering - examples

Critical Dimension Metrology of Nanoscale Structures with Small Angle X-ray Scattering

NIST developing transmission saxs method capable of angstrom level precision in critical dimension evaluation over (50 x 50) mm arrays of nanoscale periodic structures



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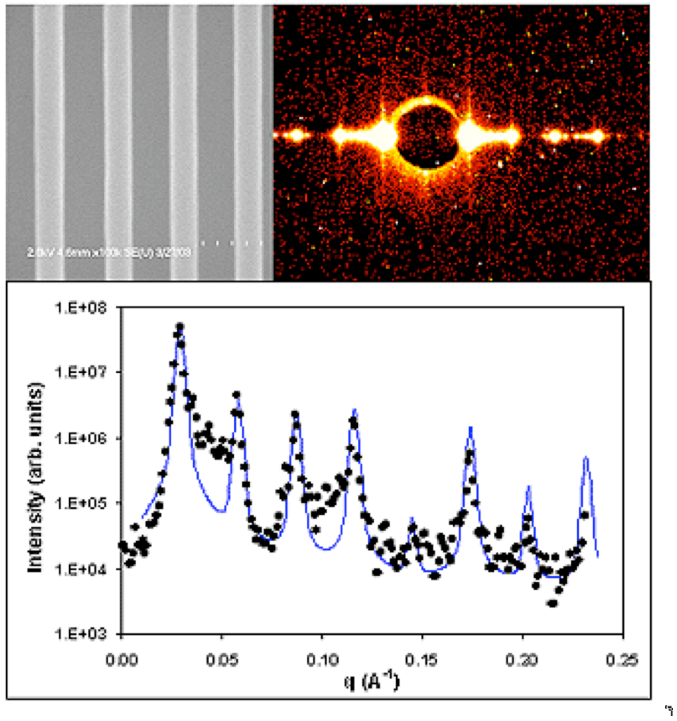
Critical Dimension Metrology of Nanoscale Structures with Small Angle X-ray Scattering

SEM image of a photoresist grating
on a silicon wafer & resulting
2-D SAXS image



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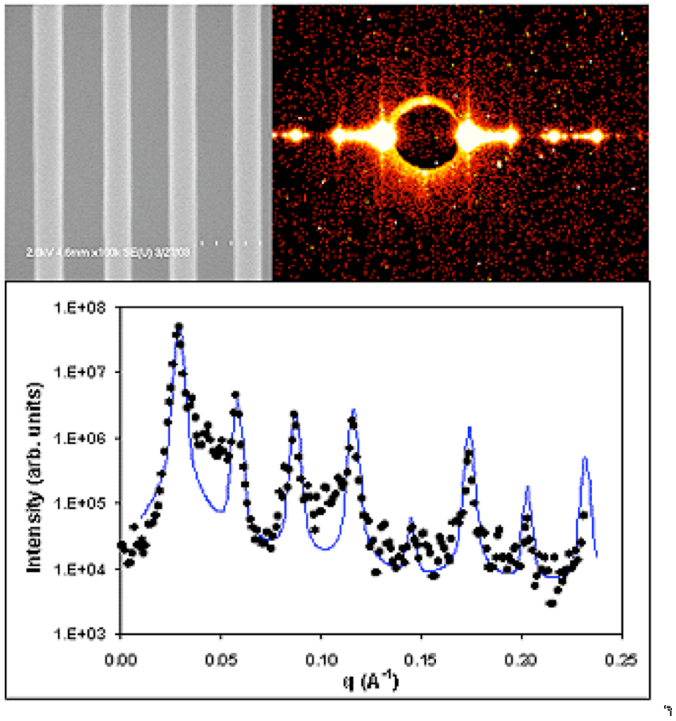
Critical Dimension Metrology of Nanoscale Structures with Small Angle X-ray Scattering

SEM image of a photoresist grating on a silicon wafer & resulting 2-D SAXS image

Streaks tell about deviations from ideal grating & defects such as long wavelength line edge roughness



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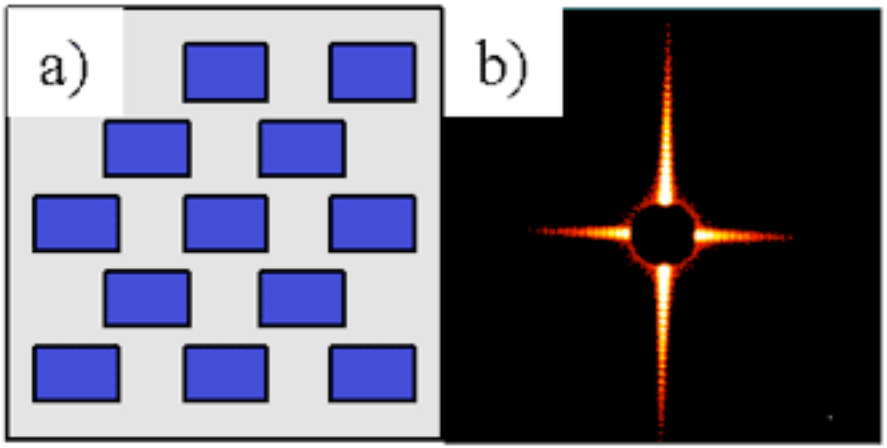

(a) blue rectangles represent etched regions in a film
(b) resulting SAXS detector image

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The measurement of the micro-fibril angle in soft-wood

Wood cell wall consists of bundles of a crystalline arrangement of cellulose chains (microfibrils)

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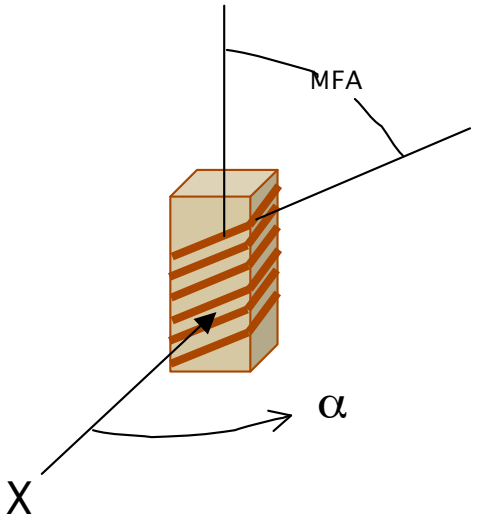
The measurement of the micro-fibril angle in soft-wood

Wood cell wall consists of bundles of a crystalline arrangement of cellulose chains (microfibrils)

Microfibrils align quite parallel in a spiral around cell wall, with spiral axis along long cell direction



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The measurement of the micro-fibril angle in soft-wood

Typical saxs patterns from Norway spruce - mean MFA of 20° - longitudinal cell axis vertical. (c) pattern recorded at α = 0°. (d) pattern recorded at α = 45°