# *Randomized Grain Boundary Phase Showing Macroscopic Chiral Domains*

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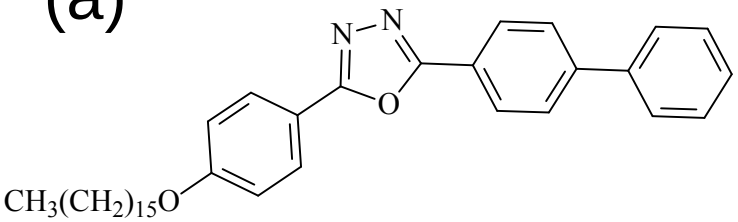
ILCC 2012, Mainz, Germany

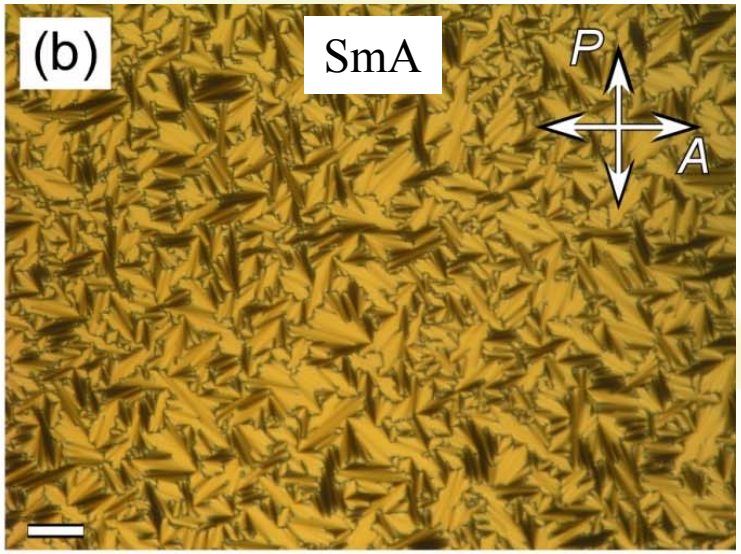
# *COBOXD and its DTLM images*

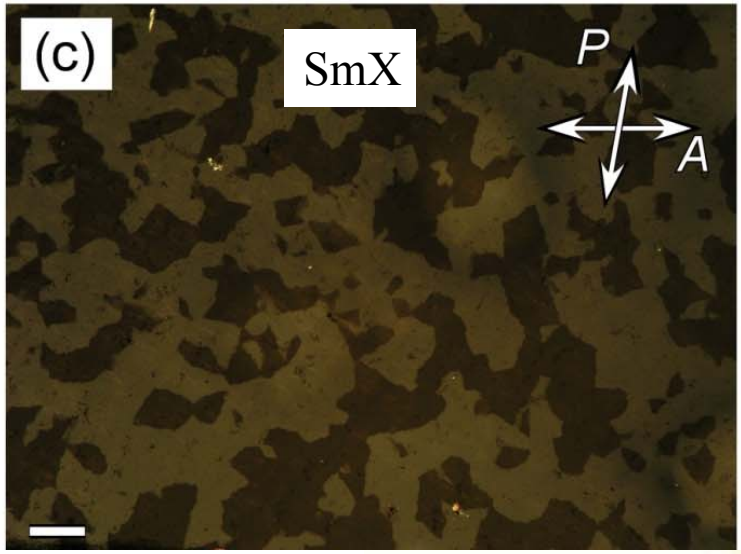
(a)

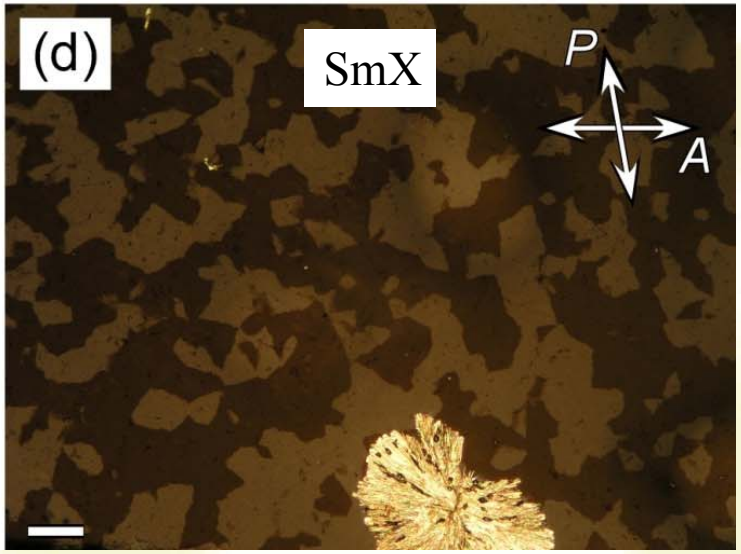



COBOXD

Iso (110°C) SmA (100°C) SmX (95°C) Cry

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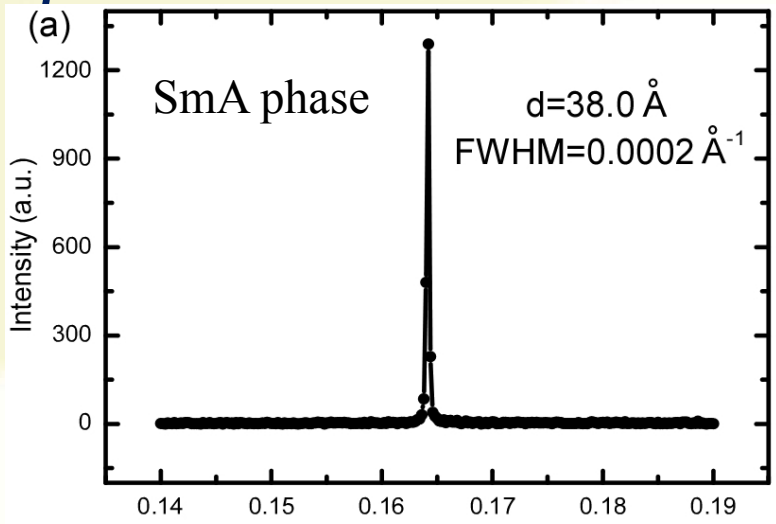
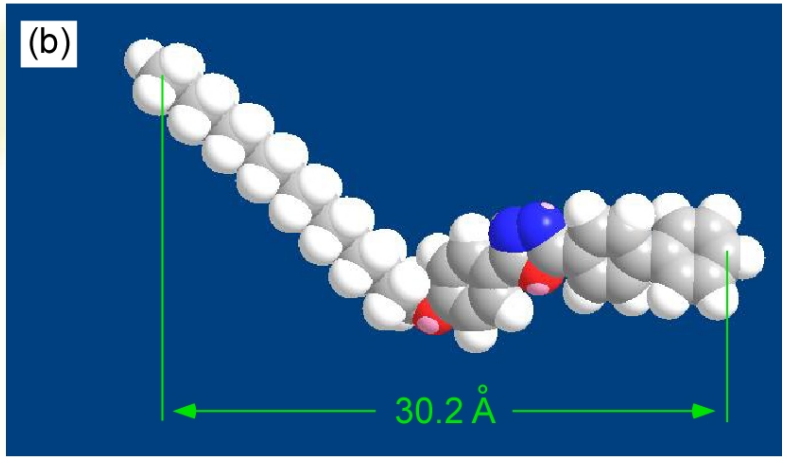
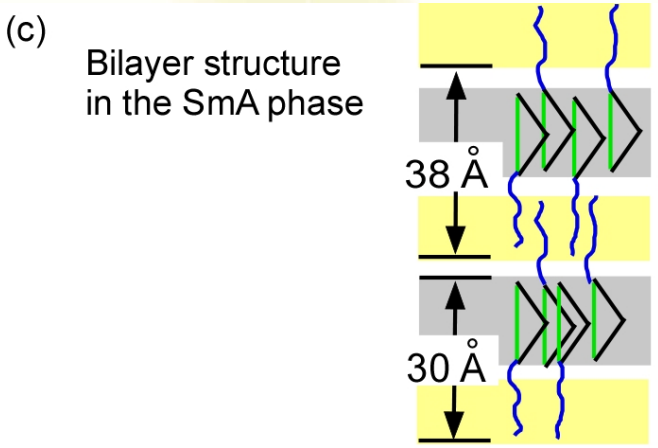
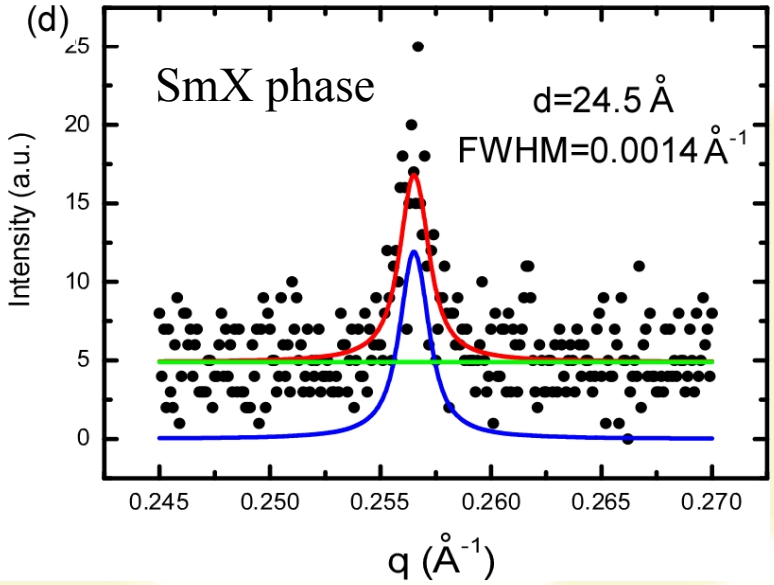
made in China

# *X-ray diffraction of the SmA and SmX phases*

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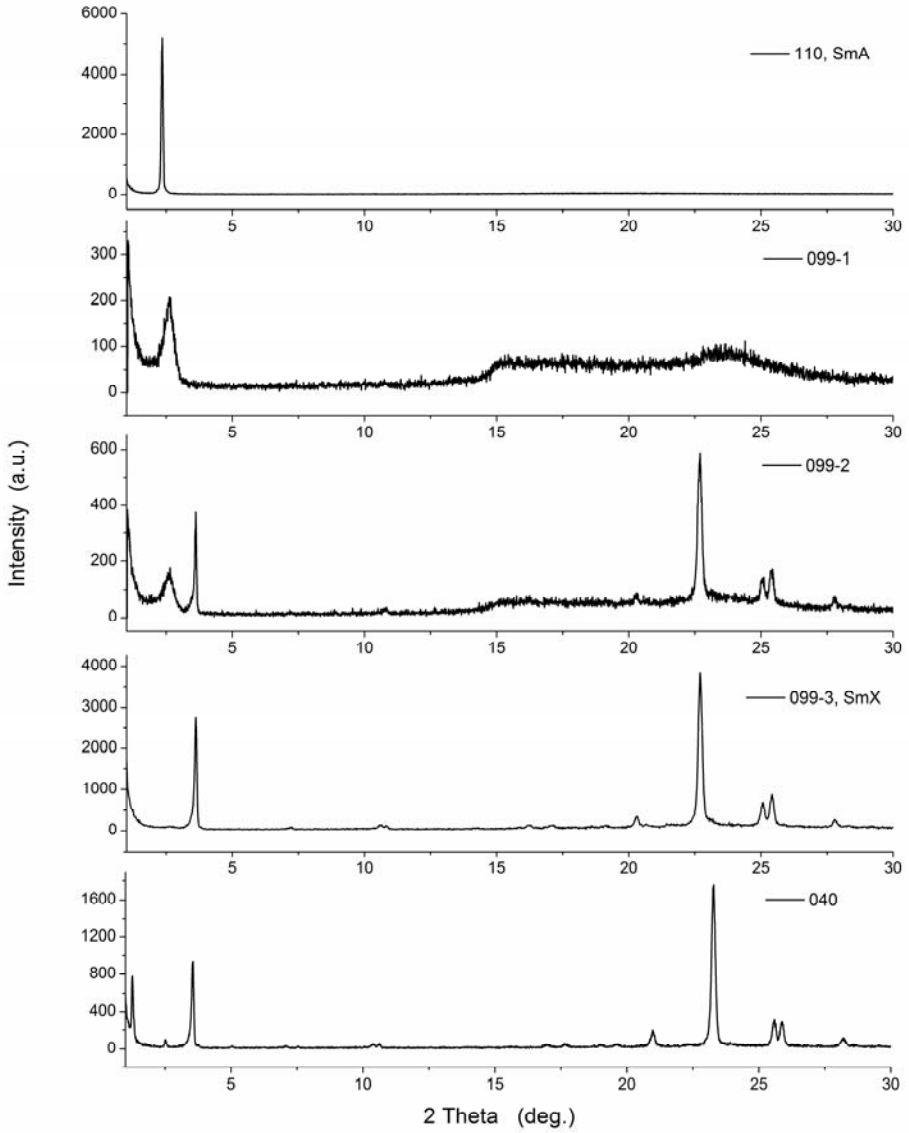
# *X-ray diffraction on cooling*




SmA Phase

SmX phase

SmX phase transition to crystal phase

Crystal Phase

Crystal Phase

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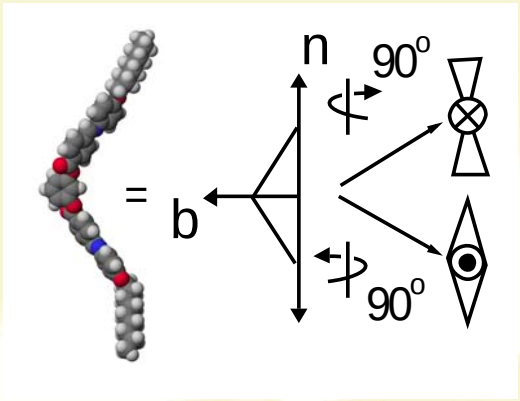
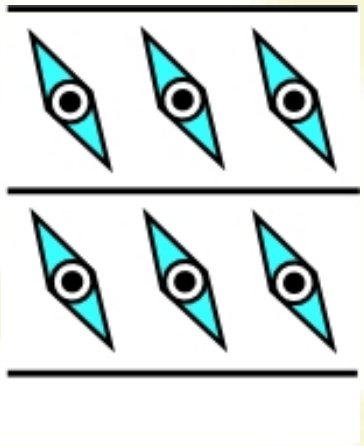
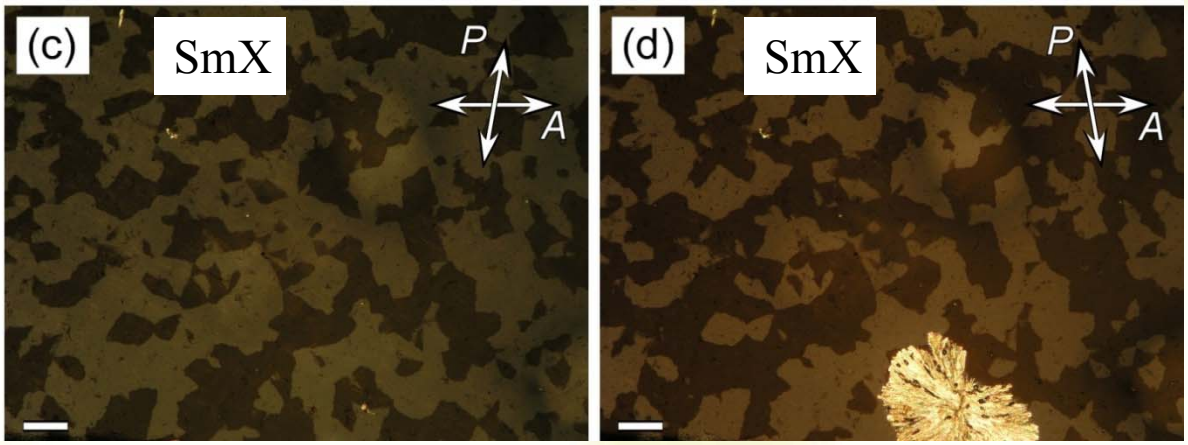
# *Chiral layers: Interplay of bent core, molecular tilt and polarization*




symmetry $C_{2d}$

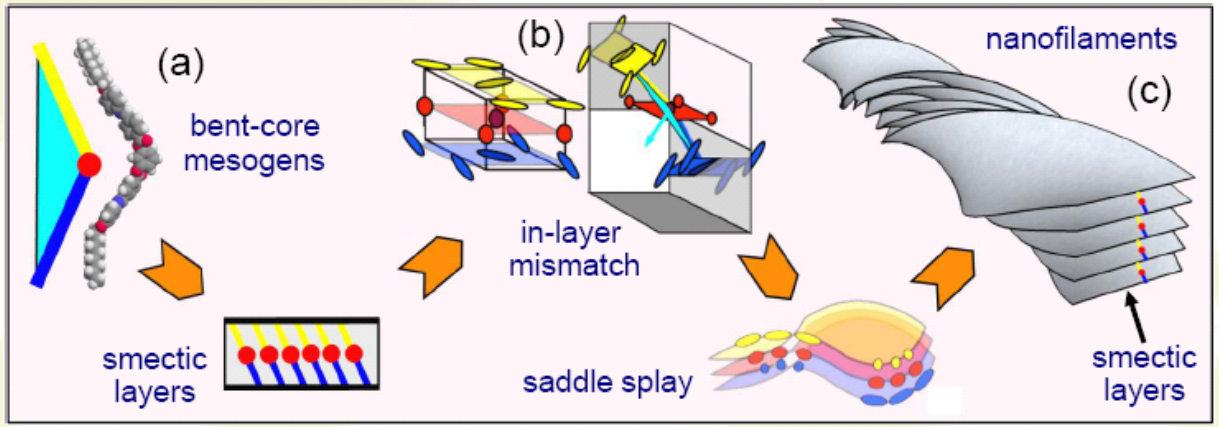


symmetry $C_2$

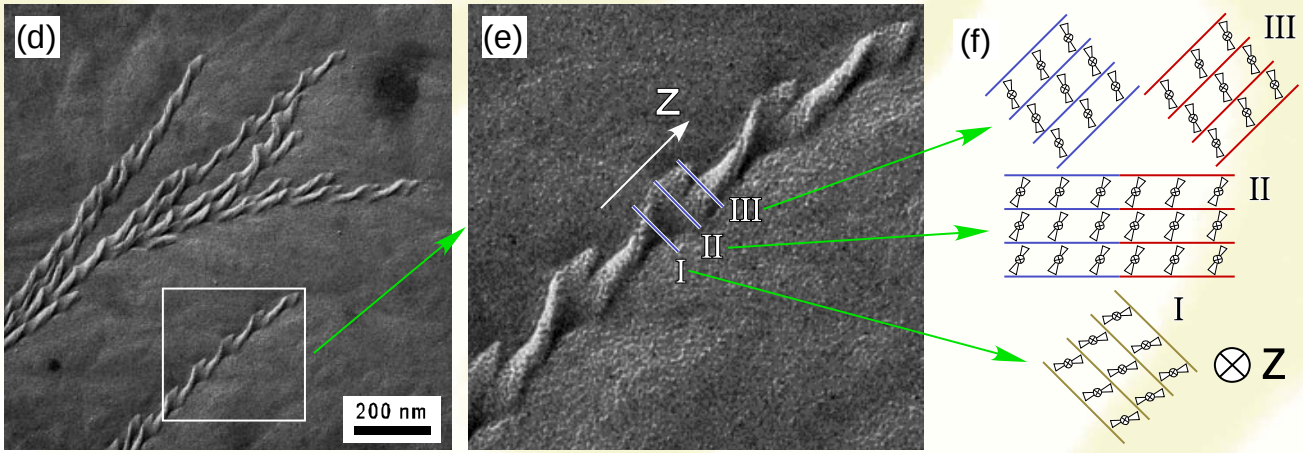


# *The B4 Phase: Helical Nanofilaments*


optical texture




self-assembly of the nanofilament phase

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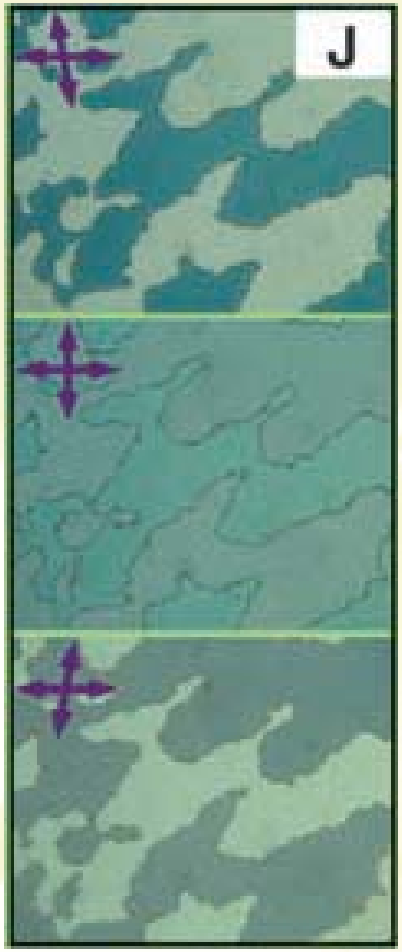
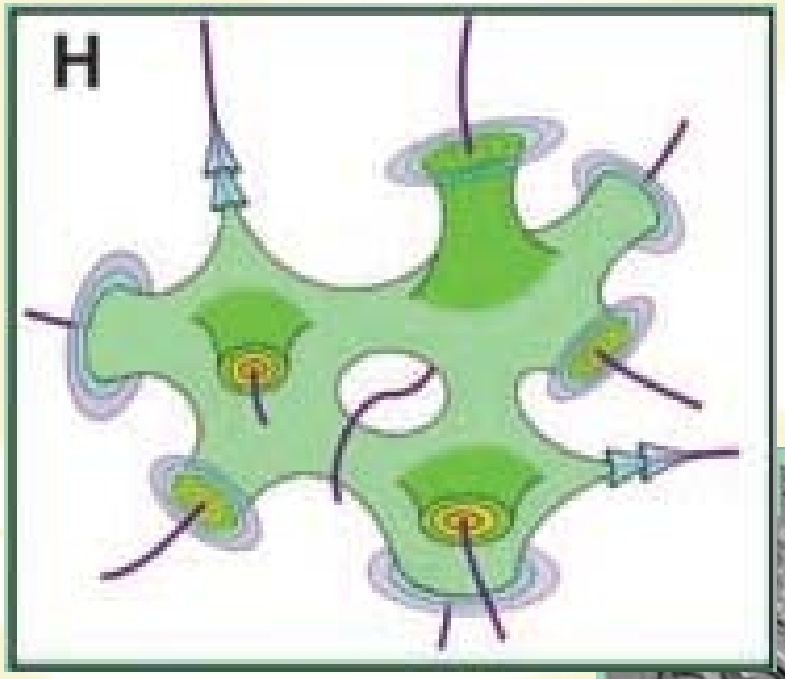
L. E. Hough et al., Science, 2009, **325**

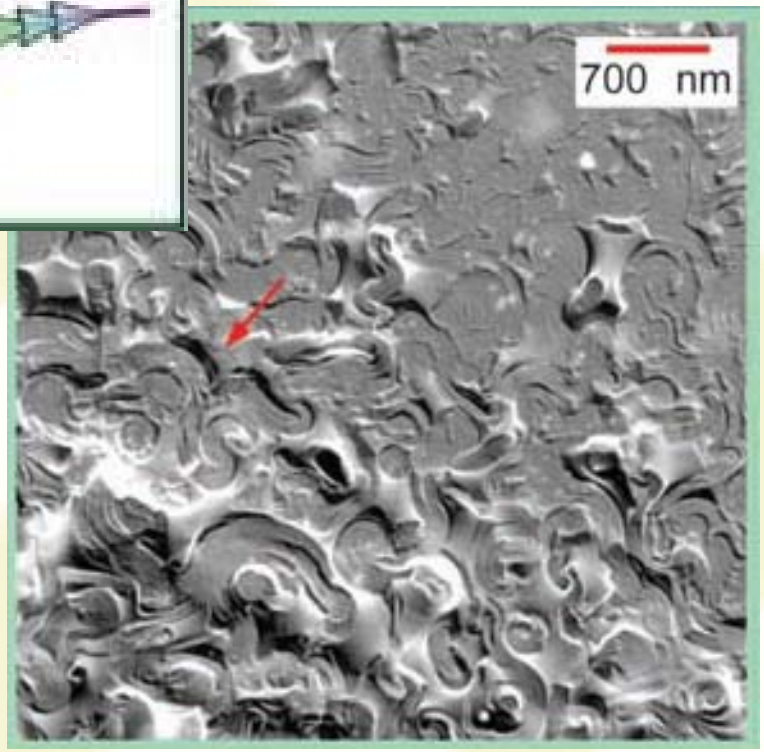
# *The DC phase: disordered focal conics*




self-assembly of disordered focal conics

optical texture




L. E. Hough et al., Science, 2009, **325**

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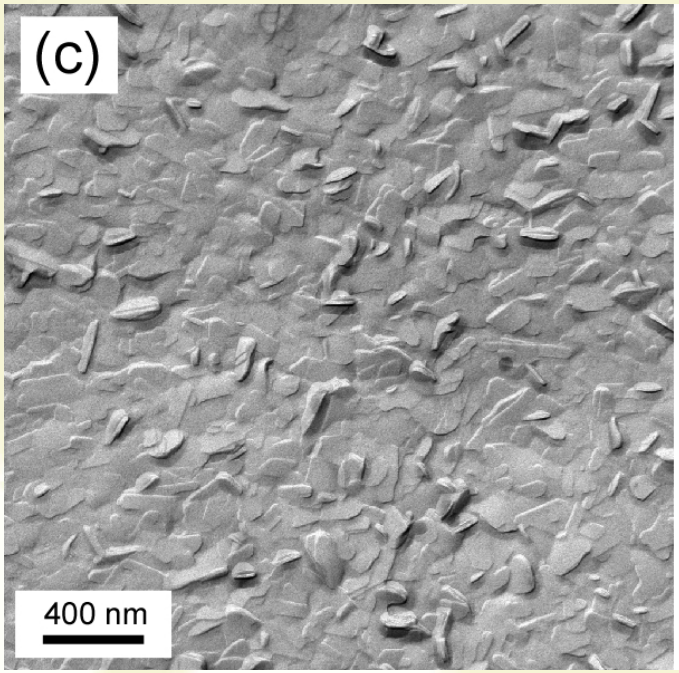
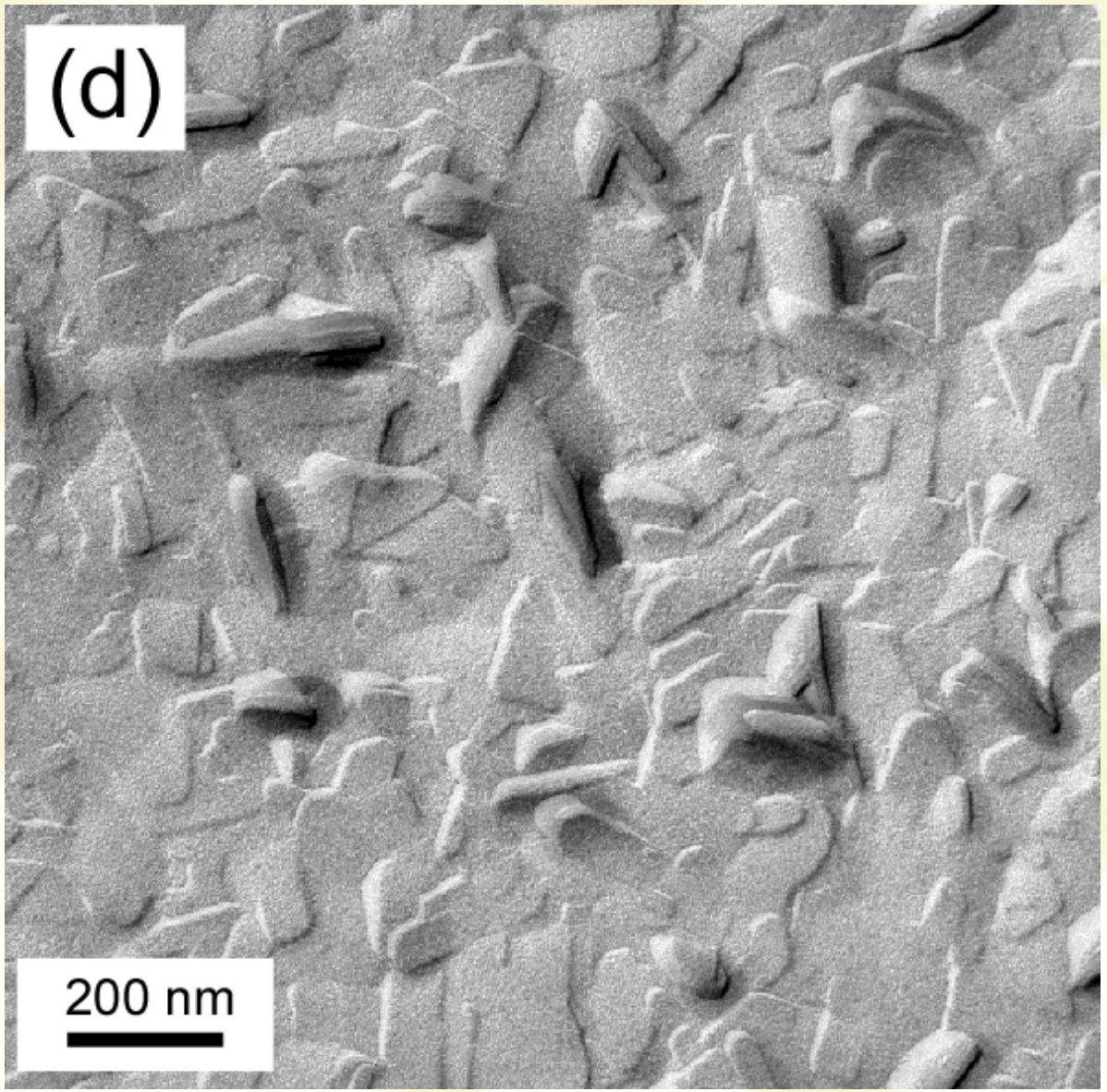
# *TEM images of the SmX phase at the air/liquid crystal interface*




Blocks of smectic layers are oriented at different directions.

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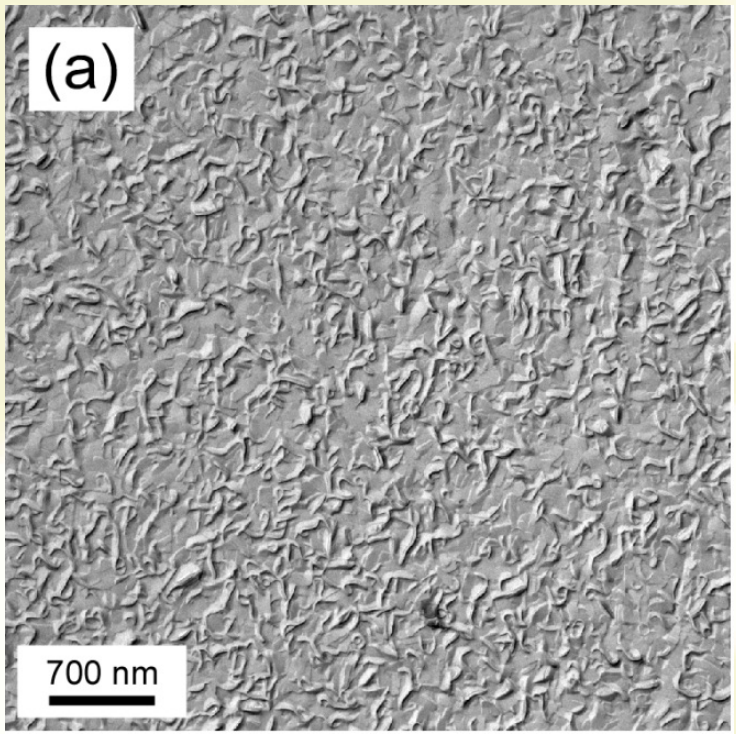
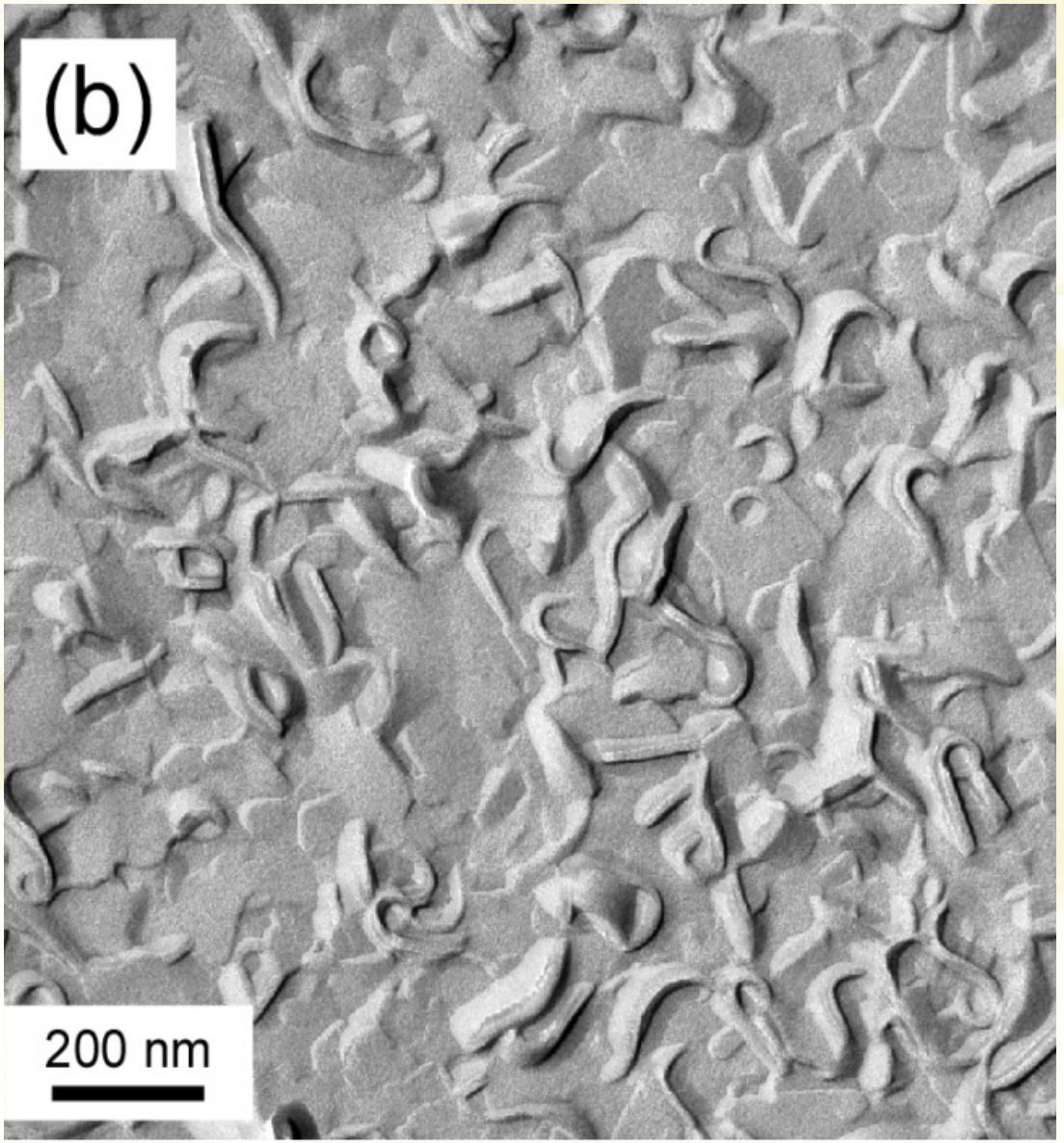
# *FFTEM image of the SmX phase fractured in the bulk*




Blocks of smectic layers are oriented at different directions.

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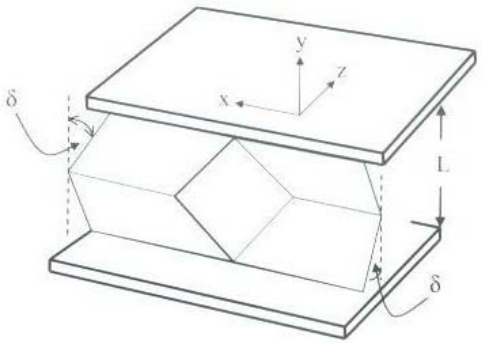
# *Chevron inclination, layer collapsing*

Fig. 7.25. Defects mediating regions of opposite (vertical) chevron inclination are essentially of the bookshelf type.



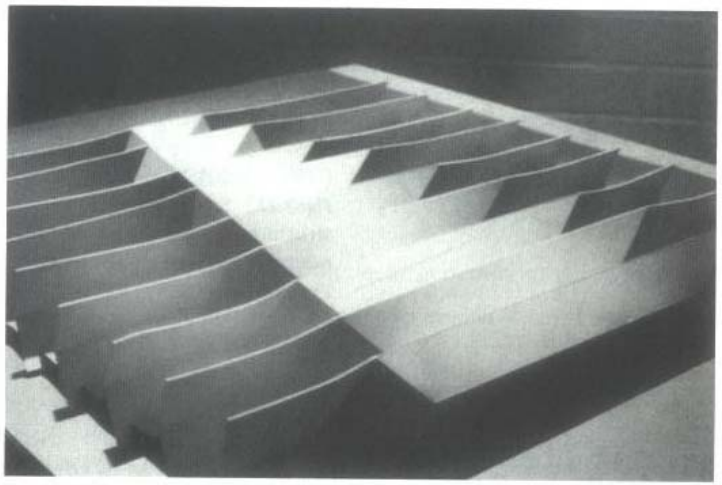
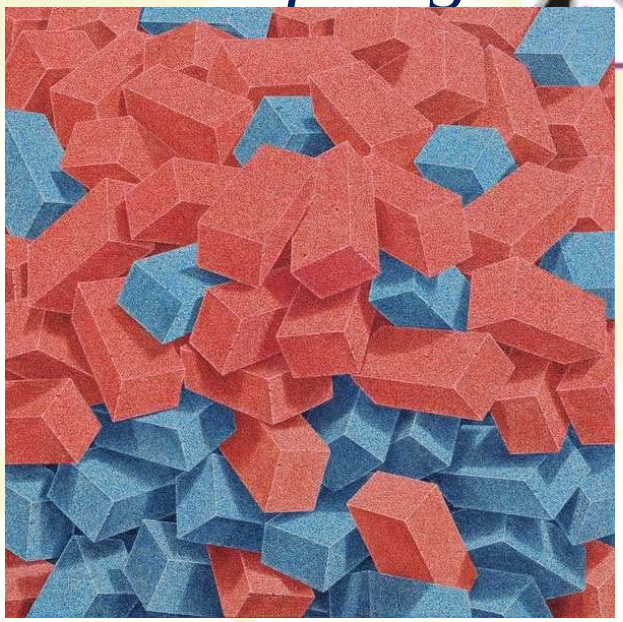
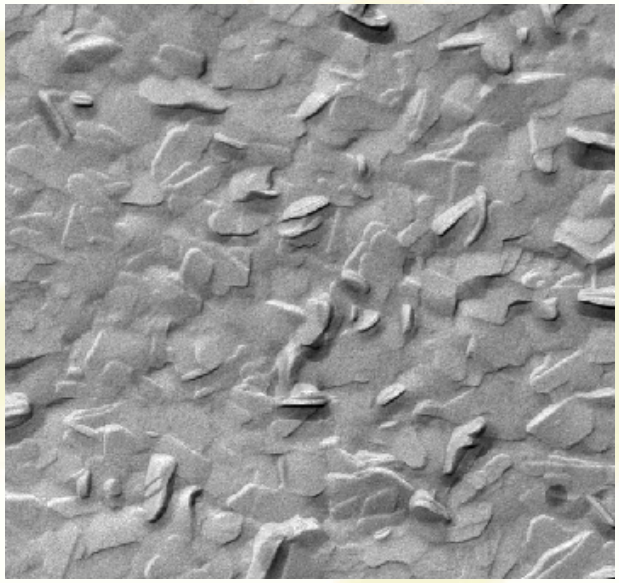



Fig. 7.26. Model of a pair of zigzag lines mediating two regions of opposite uniform (vertical) chevron inclination. Building a cardboard model of the respective structure gives an intuitive idea of why the mediating regions are oriented in bookshelf geometry, with the normal to the layer plane being tilted with respect to the rubbing direction. (Reproduced by permission of Taylor & Francis, I. Dierking et al., *Liq. Cryst.*, **19**, (1995), 179 ⟨http://www.tandf.co.uk/journals⟩.)





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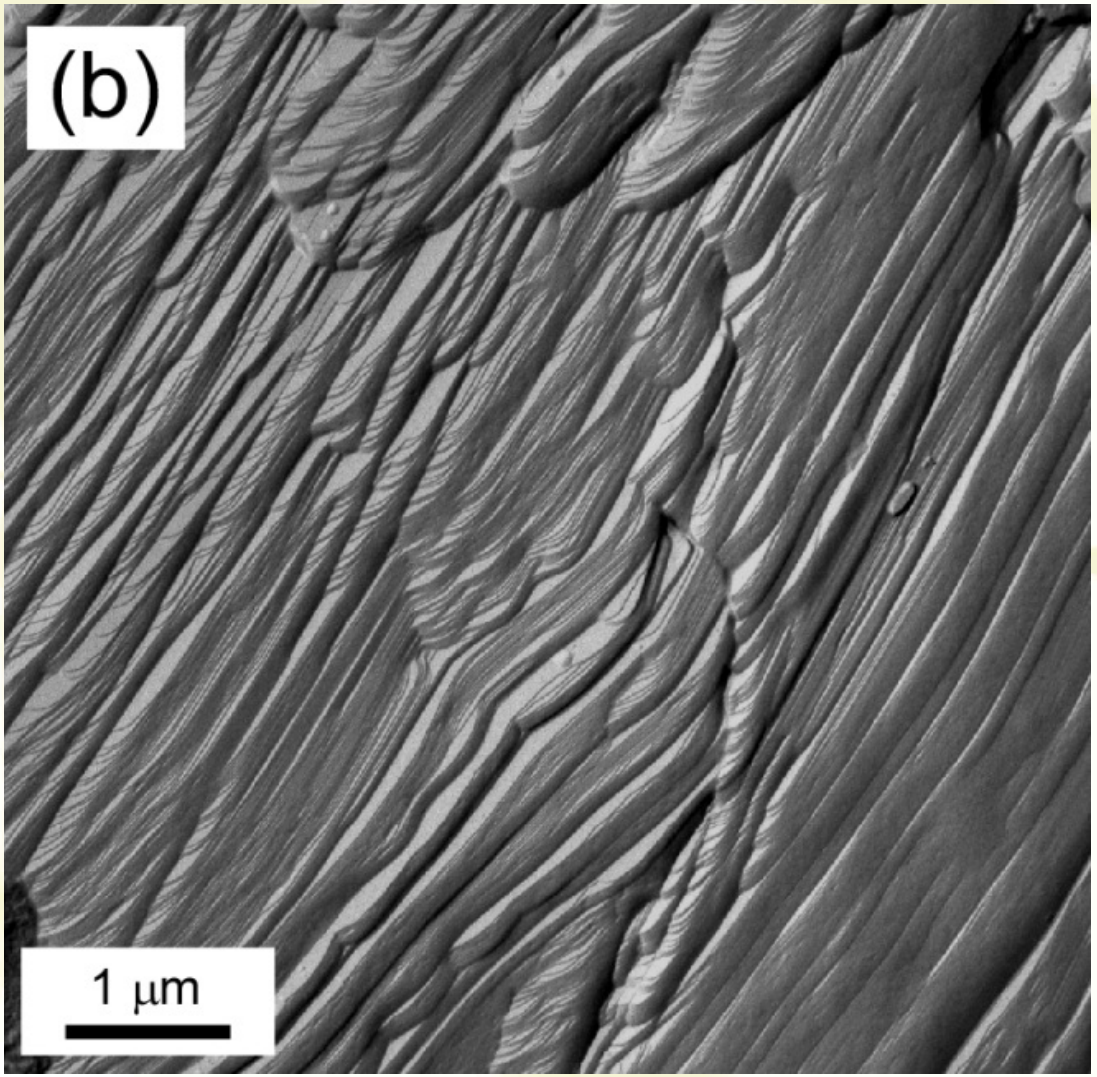
from internet

# *TEM images of the crystal phase at the air/crystal interface*

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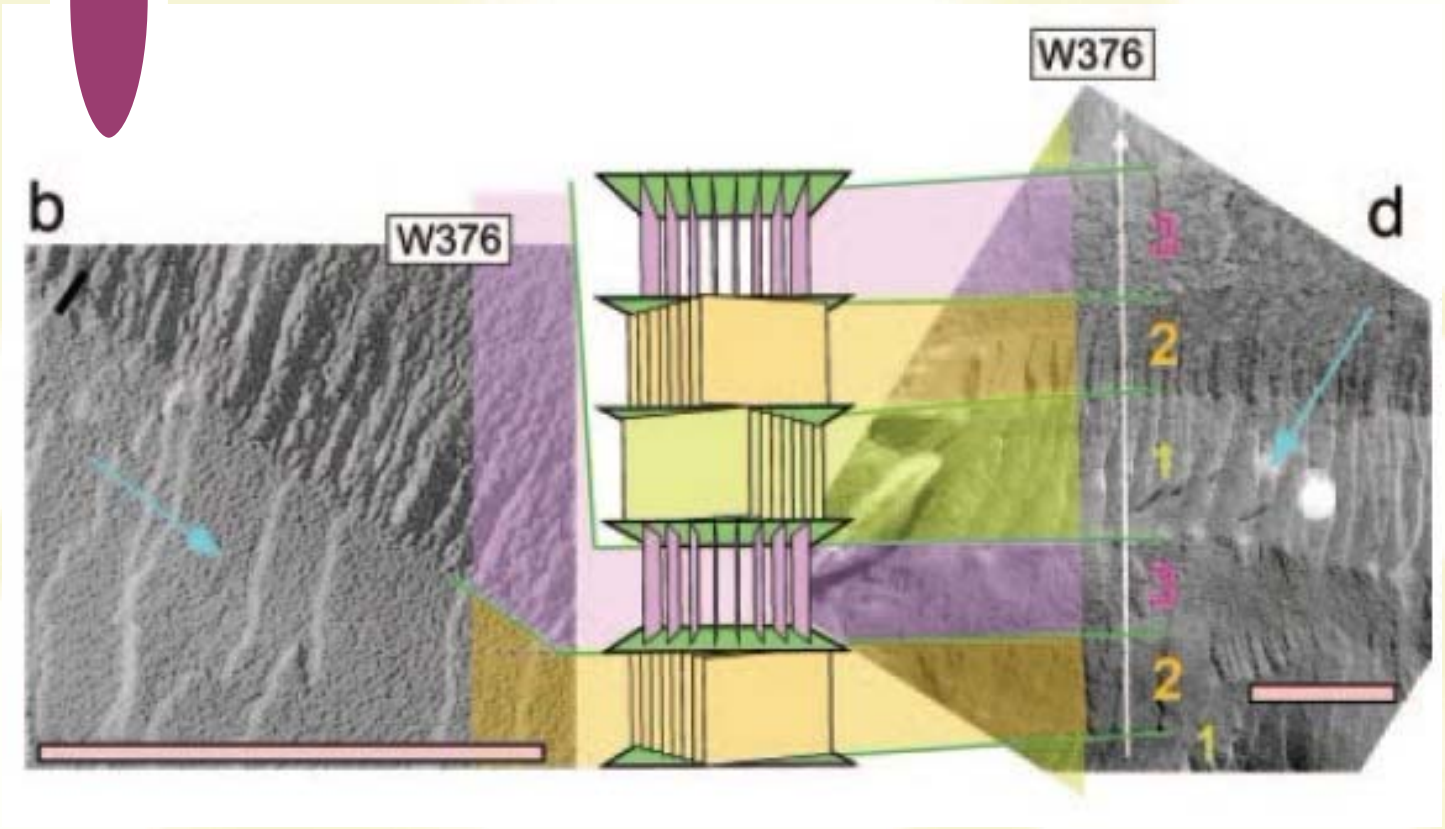
# *Twist grain boundary phase*




## *Randomized grain boundary phase*

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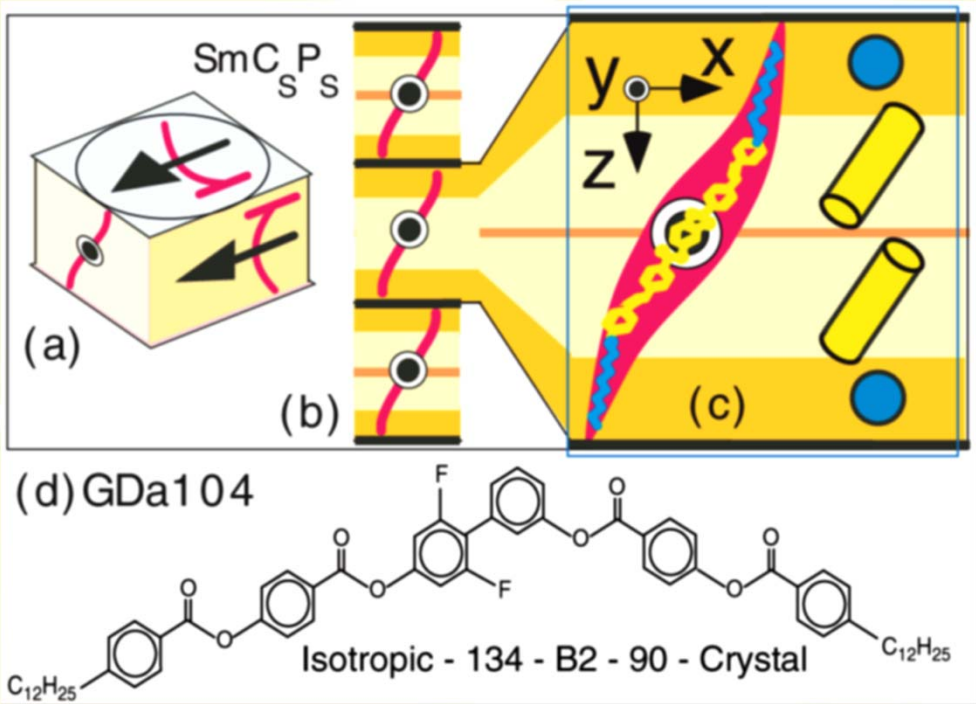
J. Fernsler et al. PNAS, 2005, **102**

# *Formation of macroscopic chiral domains in a fluid smectic phase of achiral molecules*




Theoretical calculation

$SmC_AP_A$ OR=0.1°/μm

$SmC_SP_F$ OR=0.05°/μm

Experiment

OR=0.04°/μm

For $\lambda$=650 nm

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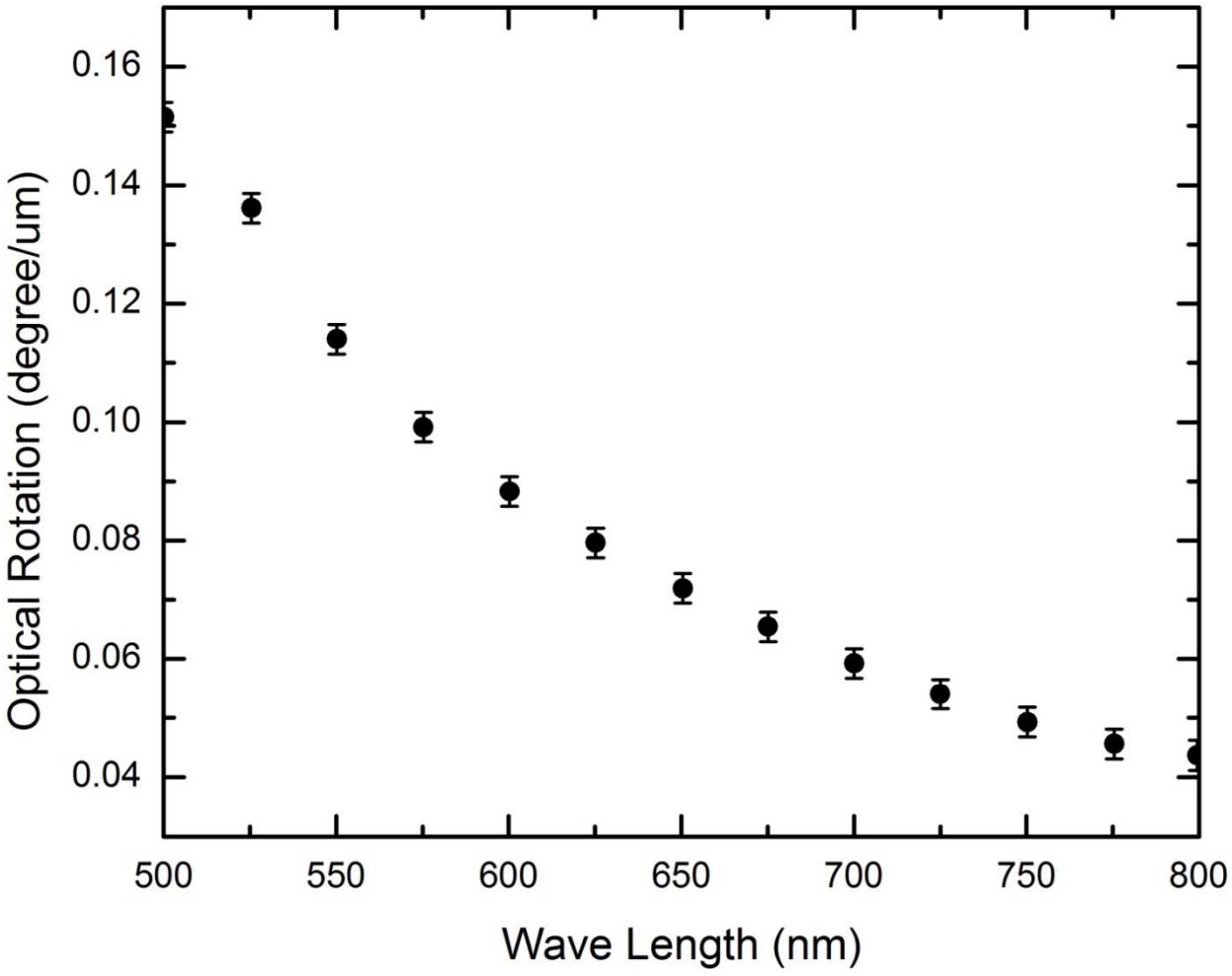
L. E. Hough et al., PRL, 2005, **95**

# *Optical rotation due to layer chirality*




OR =0.07°/μm  For $\lambda$=650 nm

The optical rotation is attributed to the layer chirality.

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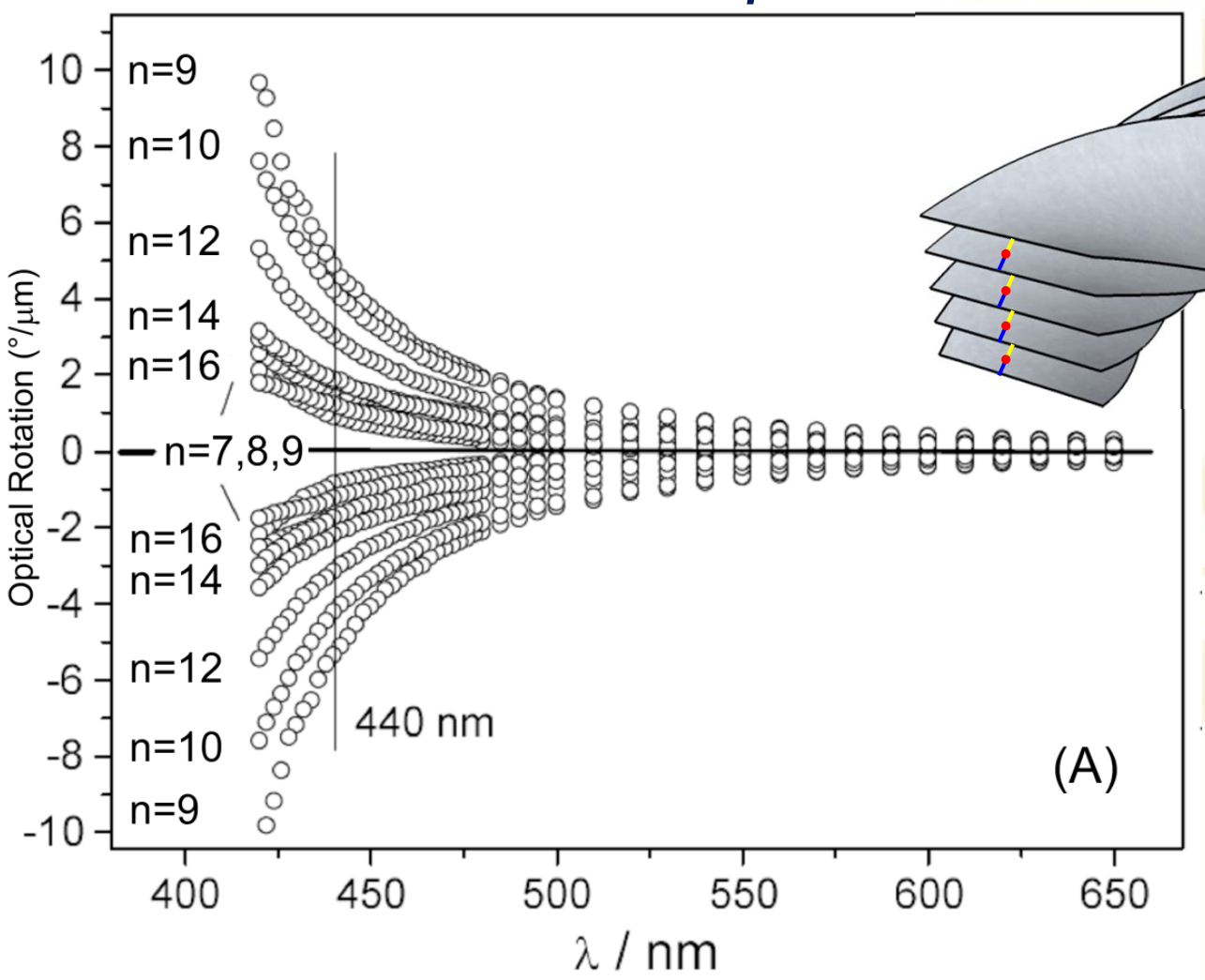
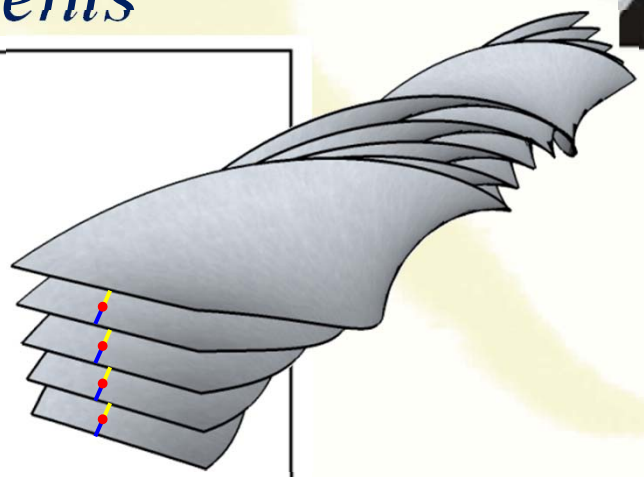
# *Optical rotation of helical nanofilaments*



OR =0.5°/μm
for $\lambda$=650 nm

10 times higher
than layer chirality

Optical Rotation of the B4 phase in the homolog series, P-n-OPIMB.

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# *Summary*

1) Randomized Grain Boundary Phase of Achiral Hockey-Stick-Like Molecule

a) showing macroscopic chiral domains.

b) made of smectic blocks, randomly oriented.

c) optical rotation purely attributed to layer chirality, no helical structure.

d) layer collapsing plays an important role in forming this phase.

2) New molecular structure self-assembles into new microstructures.

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# *Acknowledgement*

Thank you for your attention!

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through ICAM-I2CAM, 1 Shields Avenue, Davis, CA 95616, USA.

This work was supported by NSF MRSEC Grant DMR-0820579 and NSF Grant DMR-0606528.

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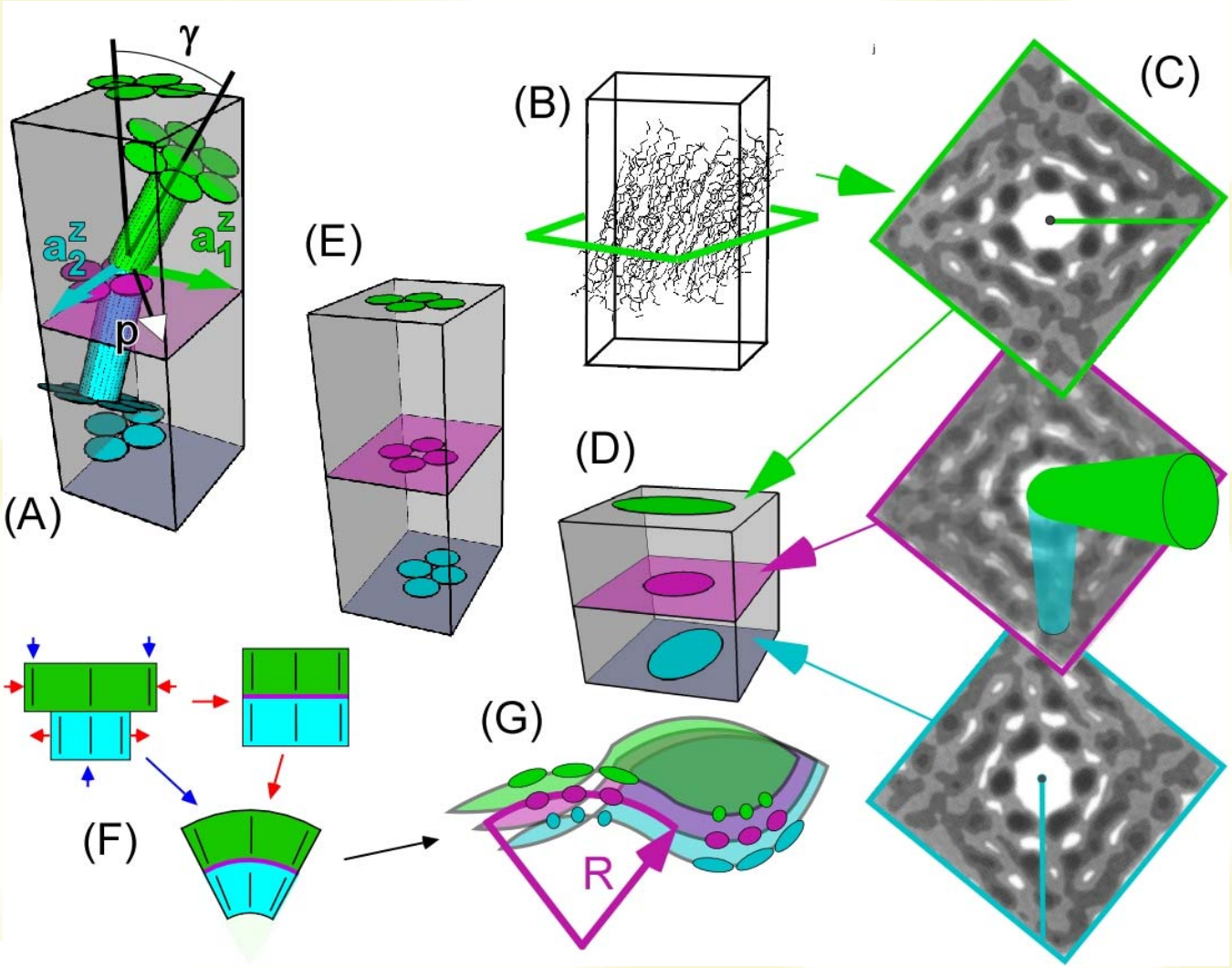
# *Saddle-splay curvature: Driven by the intra-layer structural mismatch*

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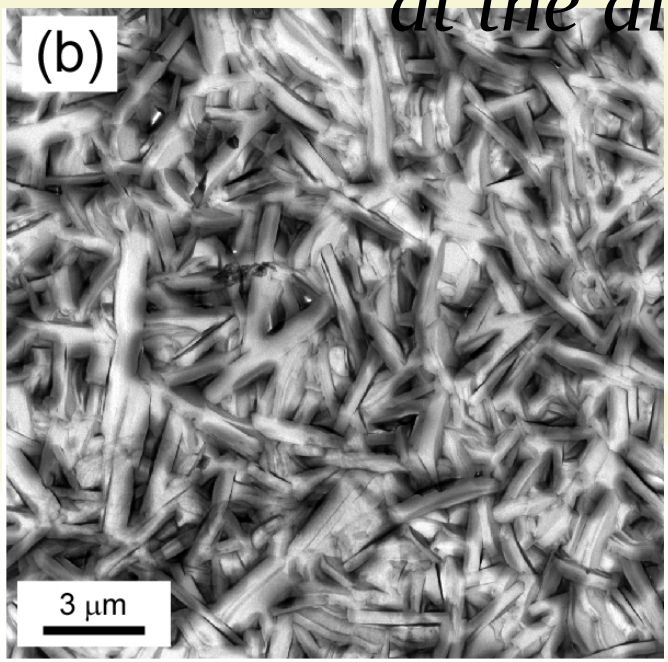
## specific rotation

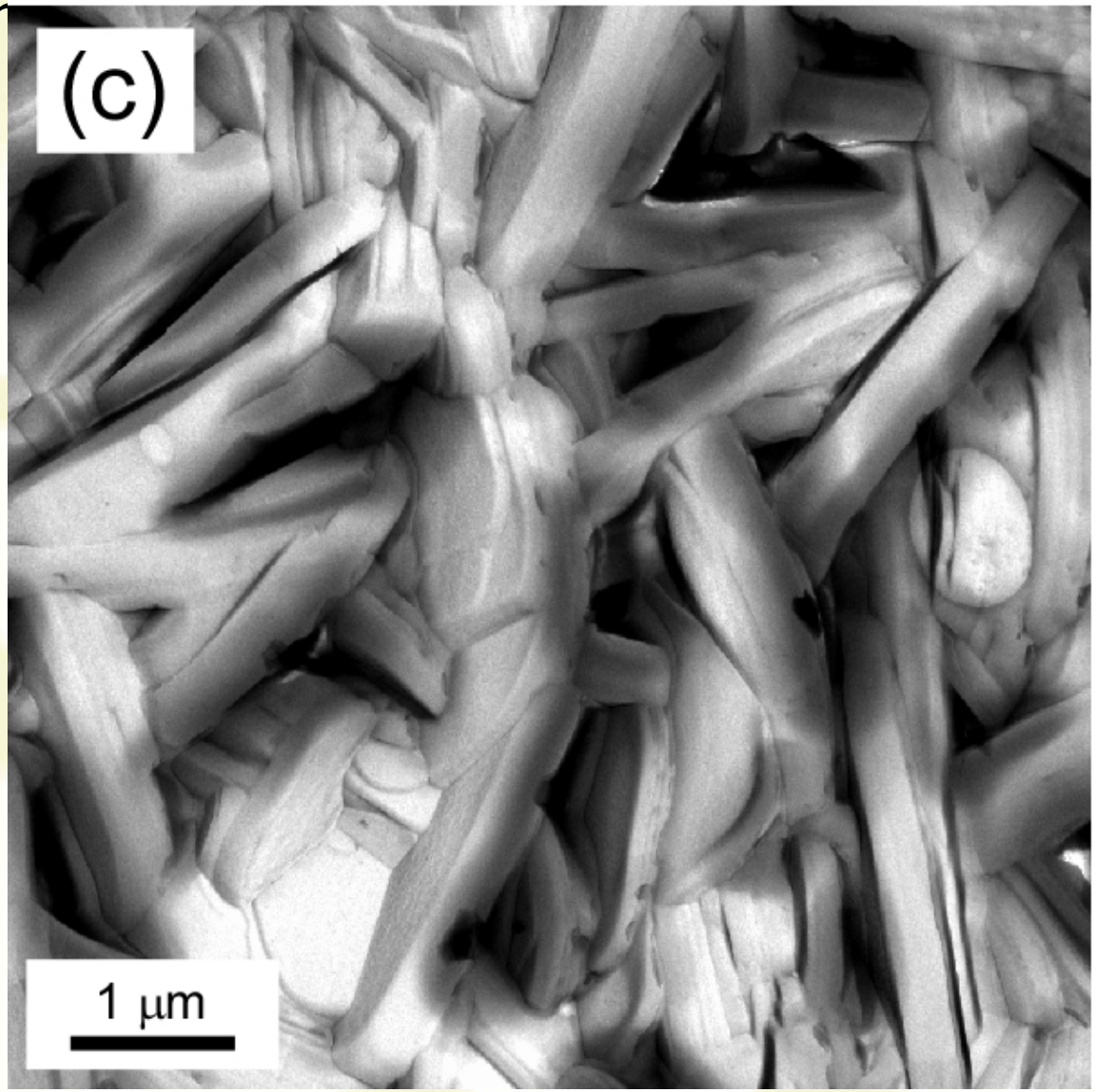
$$[a]_{\lambda}^{T} = \alpha/lc$$

α = observed rotation in degrees.
l = cell path length in decimeters. (1 decimeter = 1 dm = 10 cm.
A standard polarimeter tube is 1.00 dm in length.)
c = concentration in g $ml^{-1}$ for a pure liquid compound
(i.e., the liquid's density), or g 100 $ml^{-1}$ for a solution.

- Sucrose +66.47°
- Lactose +52.3°
- Cholesterol −31.5°
- Camphor +44.26°
- Penicillin V +223°
- Taxol −49°
- (S)-bromobutane +23.1°
- (R)-bromobutane −23.1°
- (+)-cavicularin +168.2°

# *TEM images of the twist grain boundary phase at the air*




Disordered blocks of smectic layer at the air interface.

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# *Outline*

1) Microstructure of the bent-core liquid crystal phases

   a) The DC phase: Disordered focal conics

   b) The B4 phase: Helical nanofilaments

2) The randomized grain boundary phase

   a) Optical texture: macroscopic chiral domain

   b) FFTEM: blocks of smectic layers

   c) Optical rotation: layer chirality

   d) XRD: layer collapsing

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