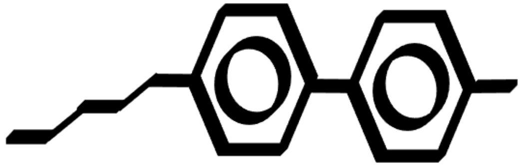
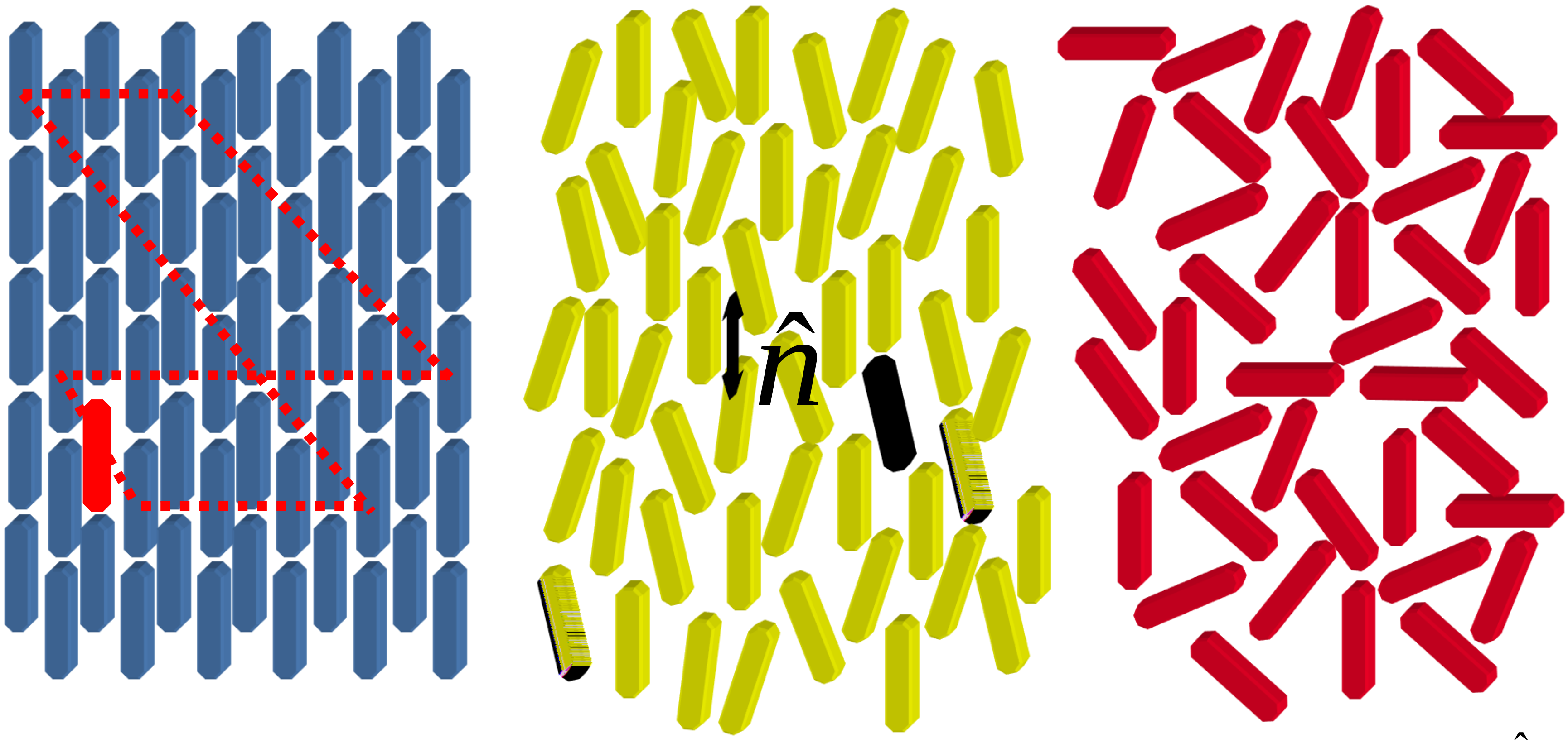
Liquid Crystals (LCs)



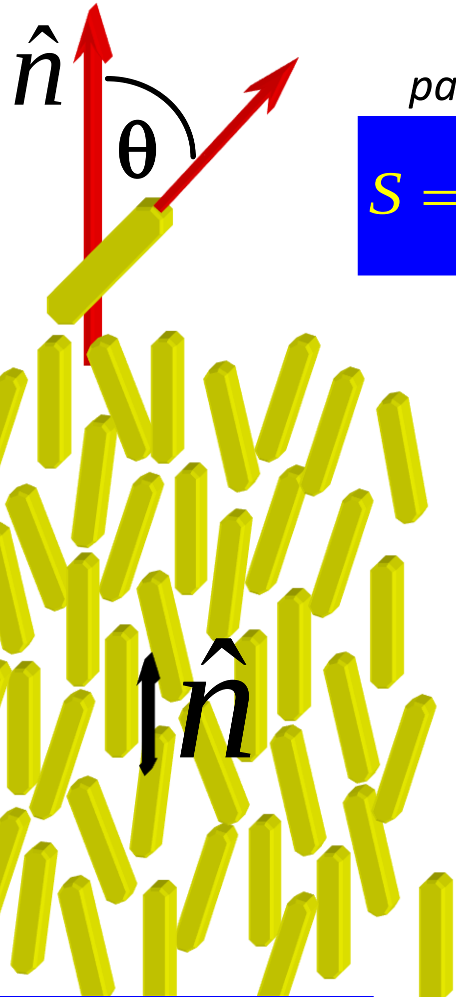


$$\hat{n} \equiv -\hat{n}$$

LC is a

e.g.

The Order Parameter



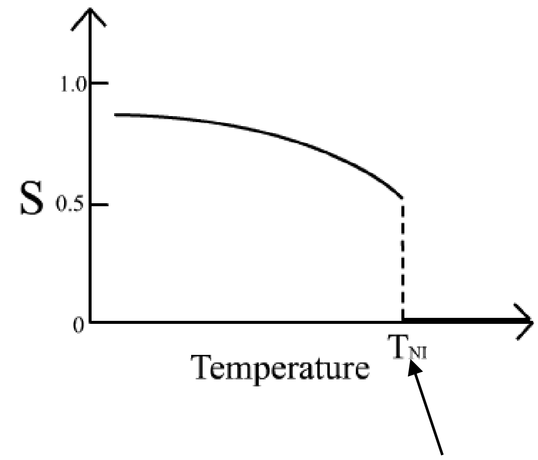
parameter

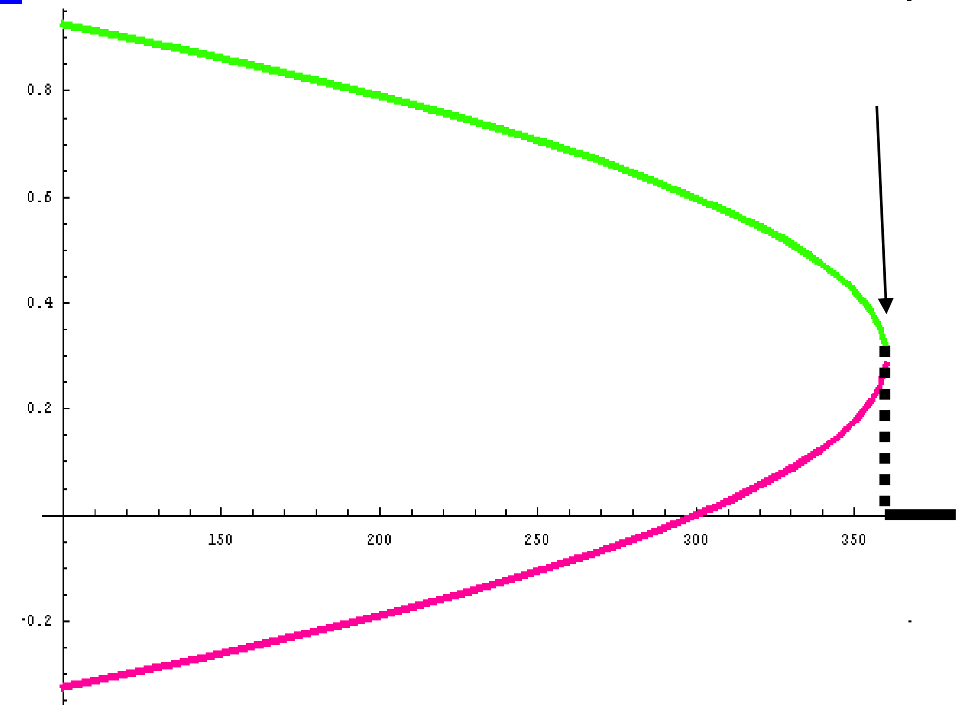
order

$$S = \langle P_2(\cos\theta)\rangle = \frac{1}{2}(3\langle \cos^2\theta\rangle - 1)$$

$$\langle \cos^2\theta\rangle = \frac{\int_\Omega \cos^2\theta\, d\Omega}{\int_\Omega d\Omega} = \frac{1}{3}$$

$$\langle \cos^2(\theta = 0^o)\rangle = 1$$





$$S = \langle P_2(\cos\theta)\rangle = 1$$

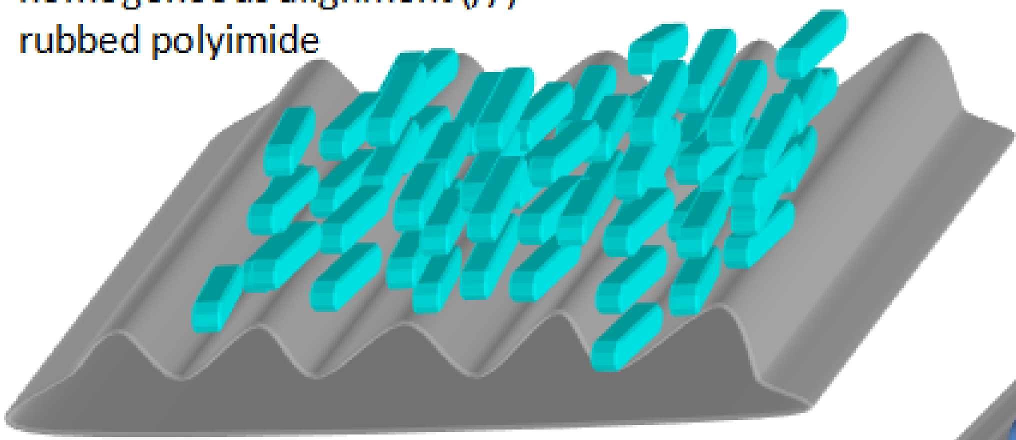
$$S = \langle P_2(\cos\theta)\rangle = 0$$

Orientational order

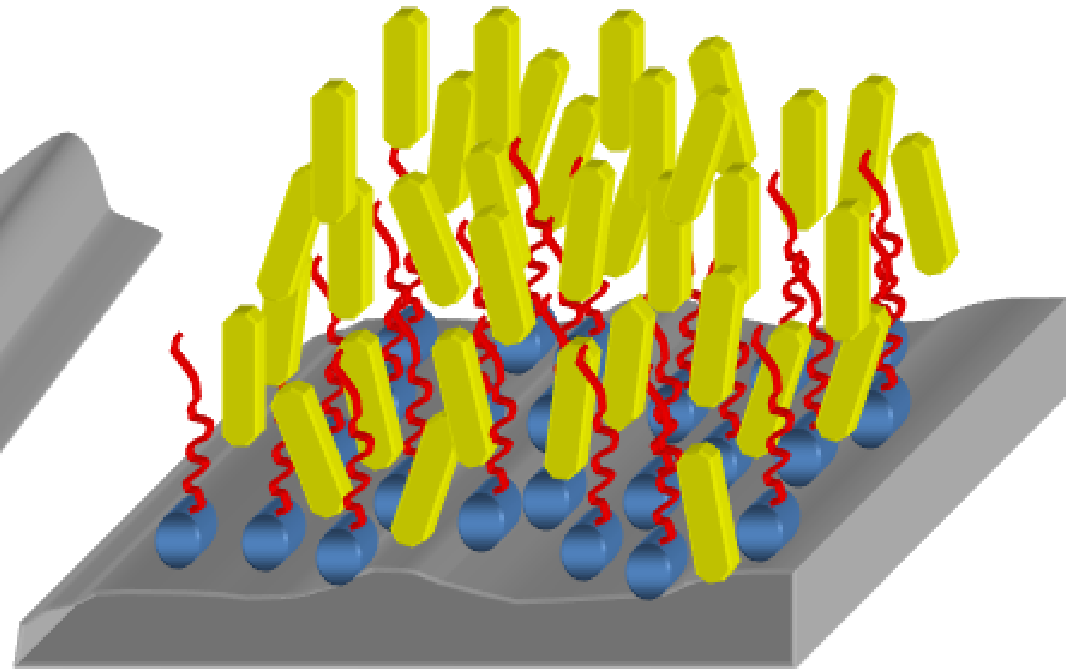
Surface Anchoring

Surface treatment allows one to control orientations of LC molecules at the surface of a solid substrate (glass plate);

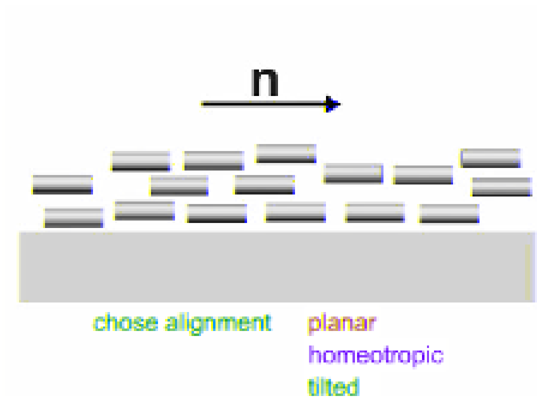
microgrooved surface - homogeneous alignment (//) rubbed polyimide



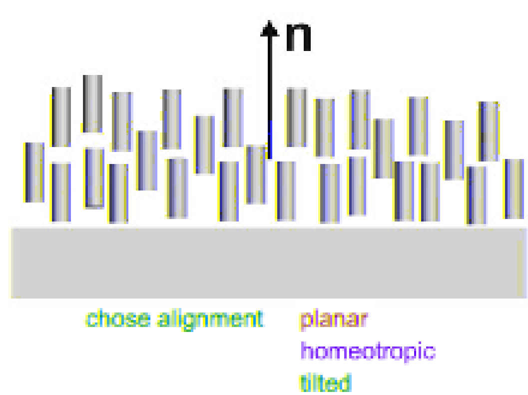
ensemble of chains - homeotropic alignment (⊥ to suface) using surfactant, polyimide, or silane molecules



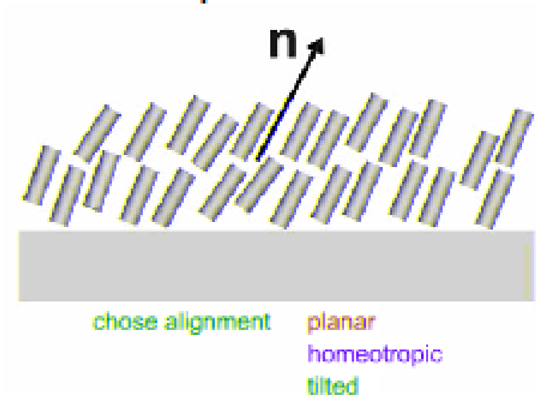
Planar



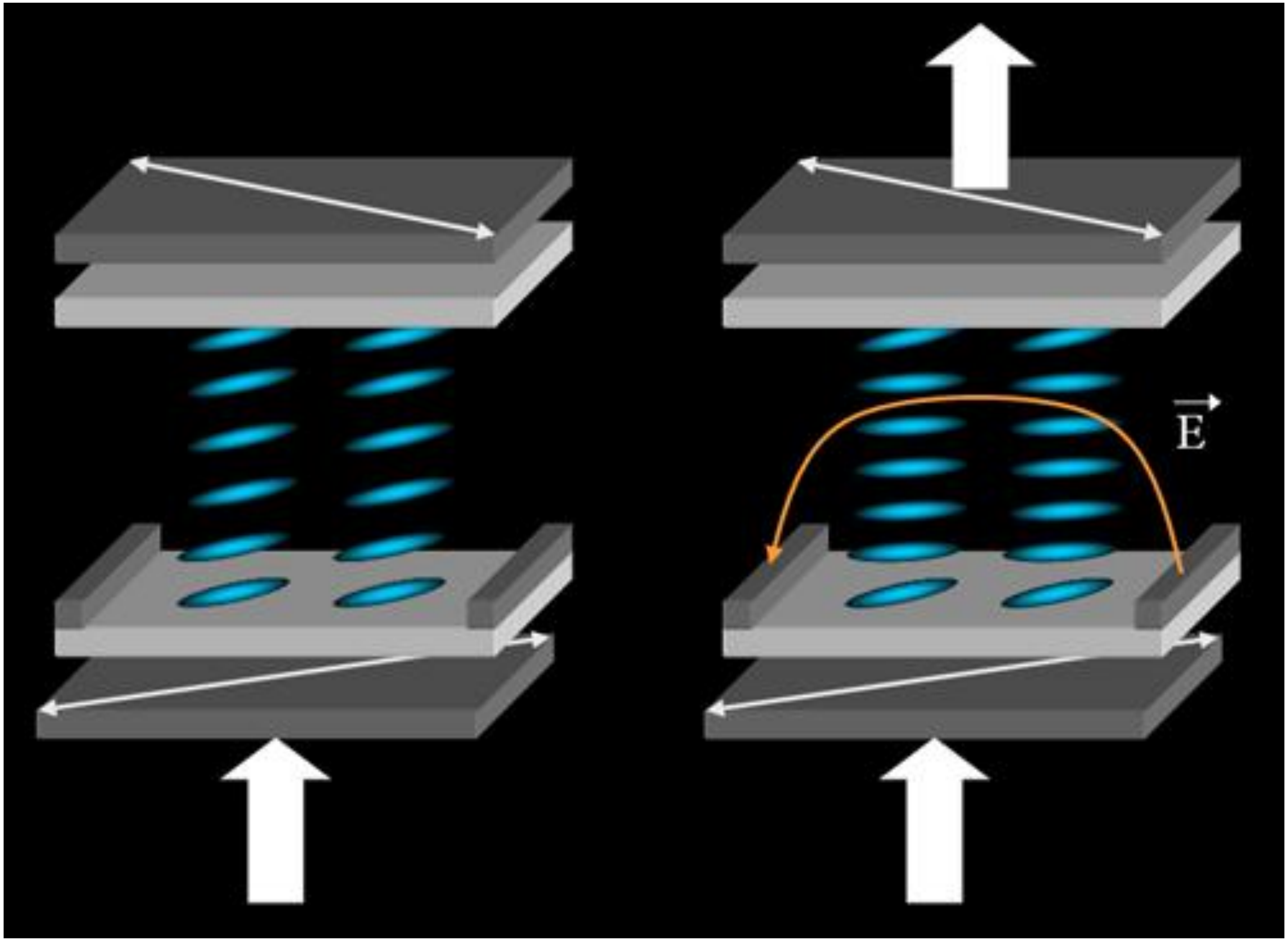
tilted



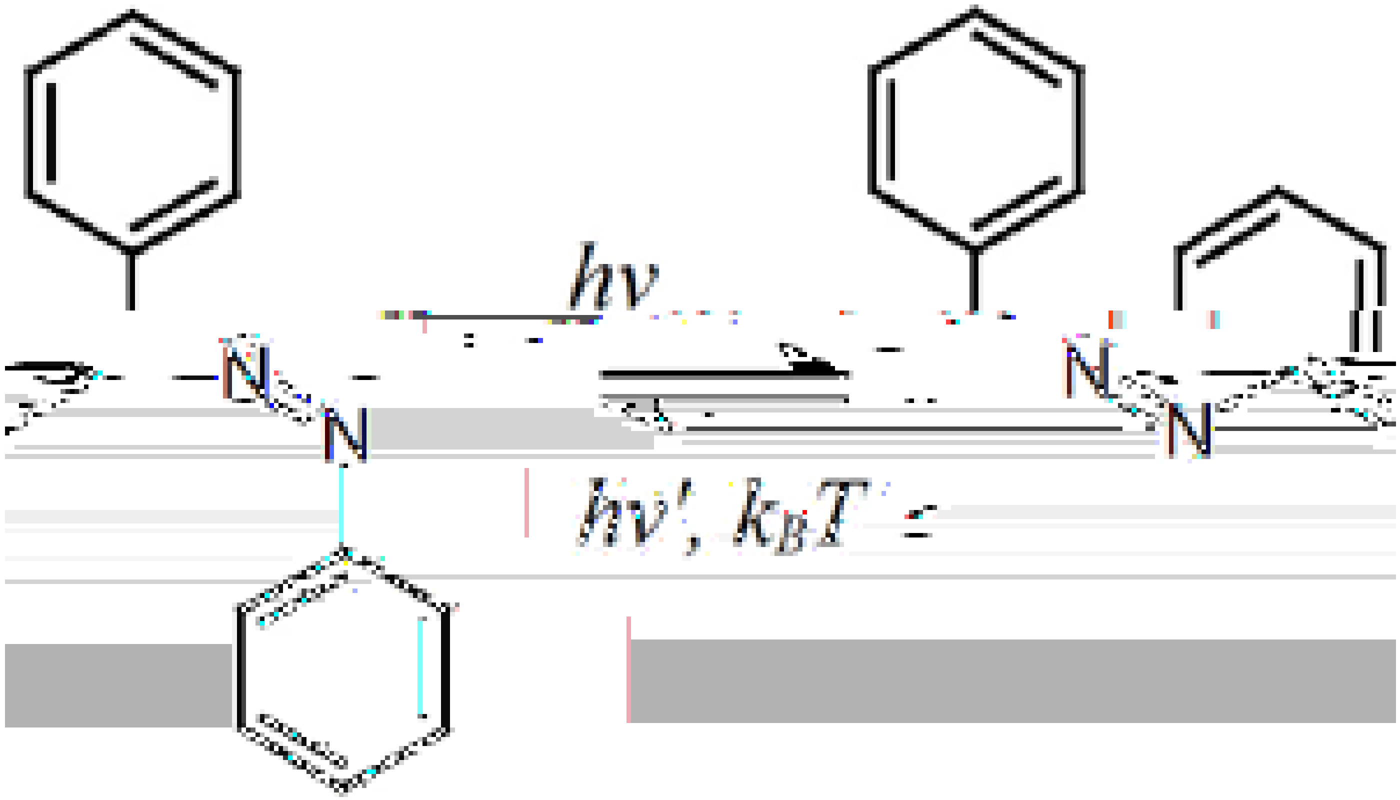
homeotropic



Alignment by external fields: IN-PLANE SWITCHING

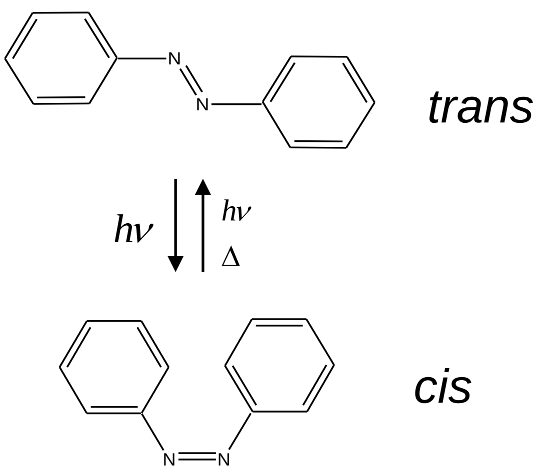


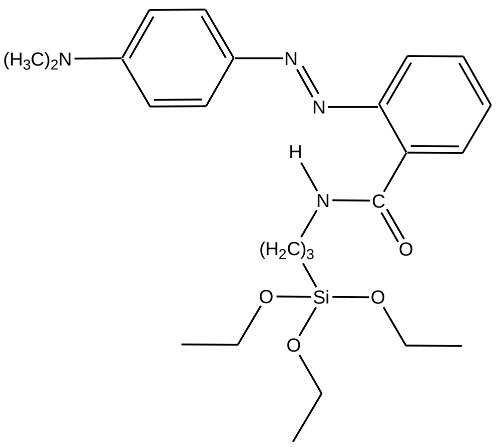
Basics of azo-benzene dye molecules and their sensitivity to light



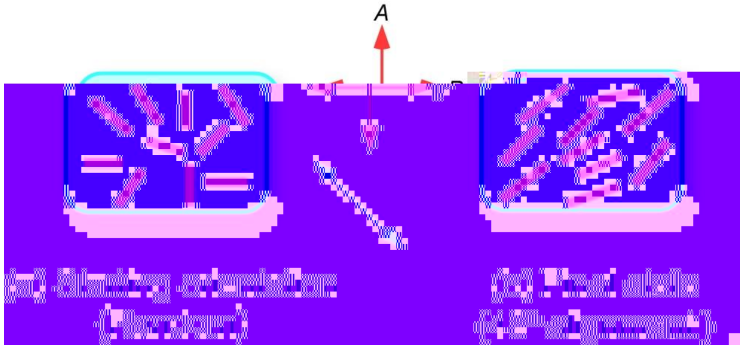
Photoisomerized dye

- Azobenzenes molecules reorient perpendicular to the polarization of the exciting light due to isomerization process .
- The methyl red derivative (DMR) is used to form self-assembled monolayers (azo-SAMs).





DMR



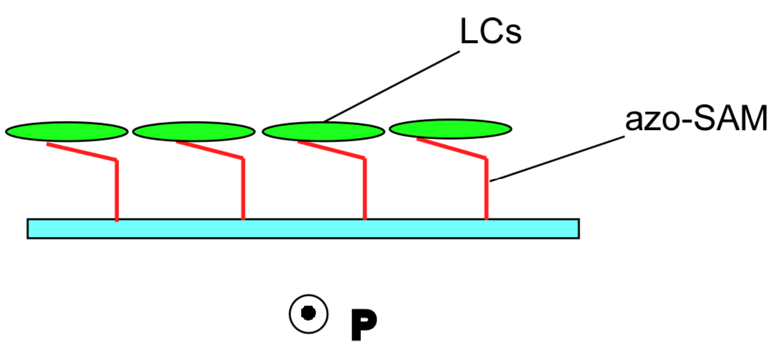
Motivation and Procedure for Producing Monolayers

- Thorough cleaning of glass slides.
    - Soap and water
    - Sonicate in IPA, Acetone, and DI water
    - Submerge and bake in Pirrahna at 90° C
- Submerge in DMR solution and bake at 45° Cx

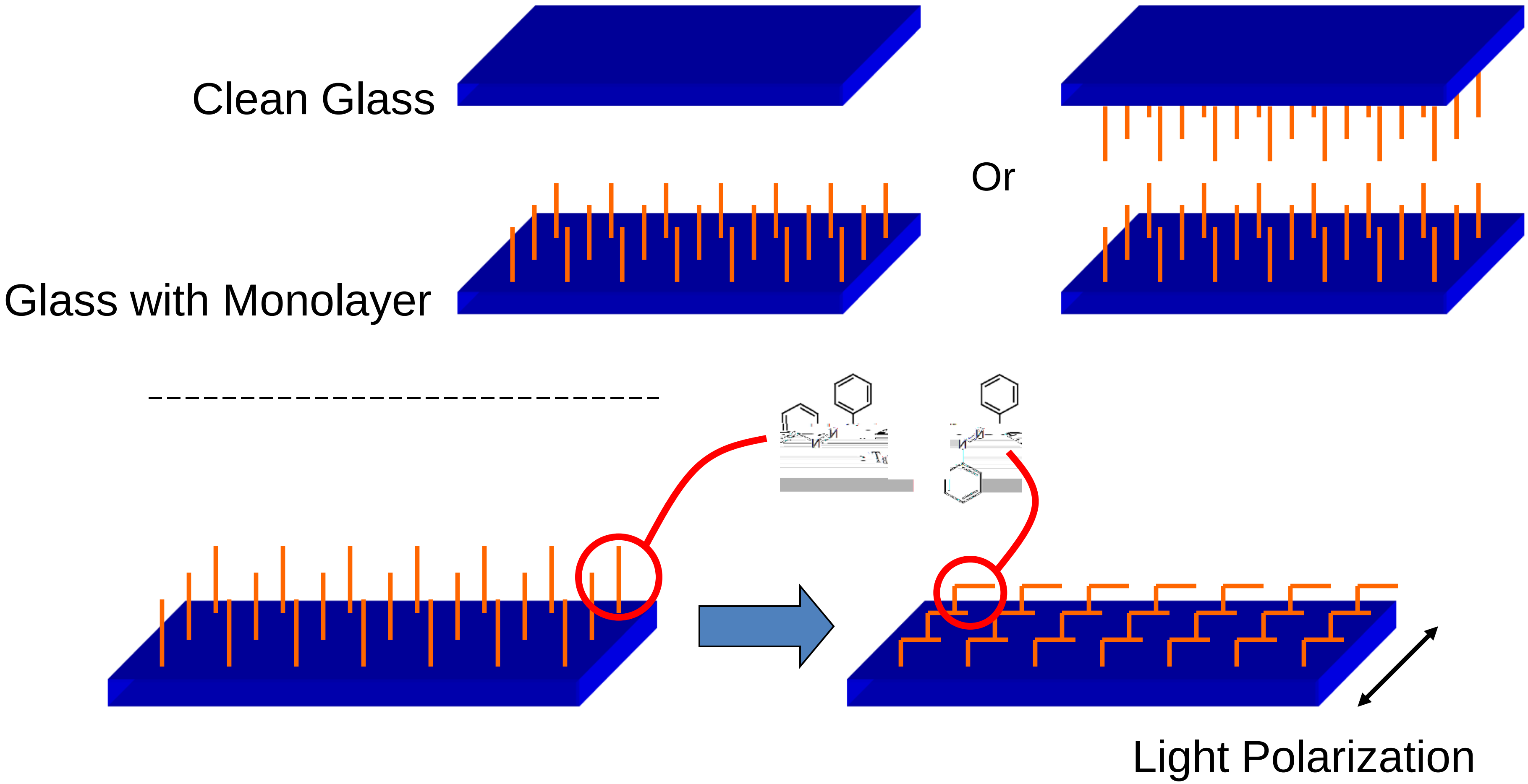
- Azo-SAM can be used to align liquid crystals (LCs).

→ Create desired boundary conditions

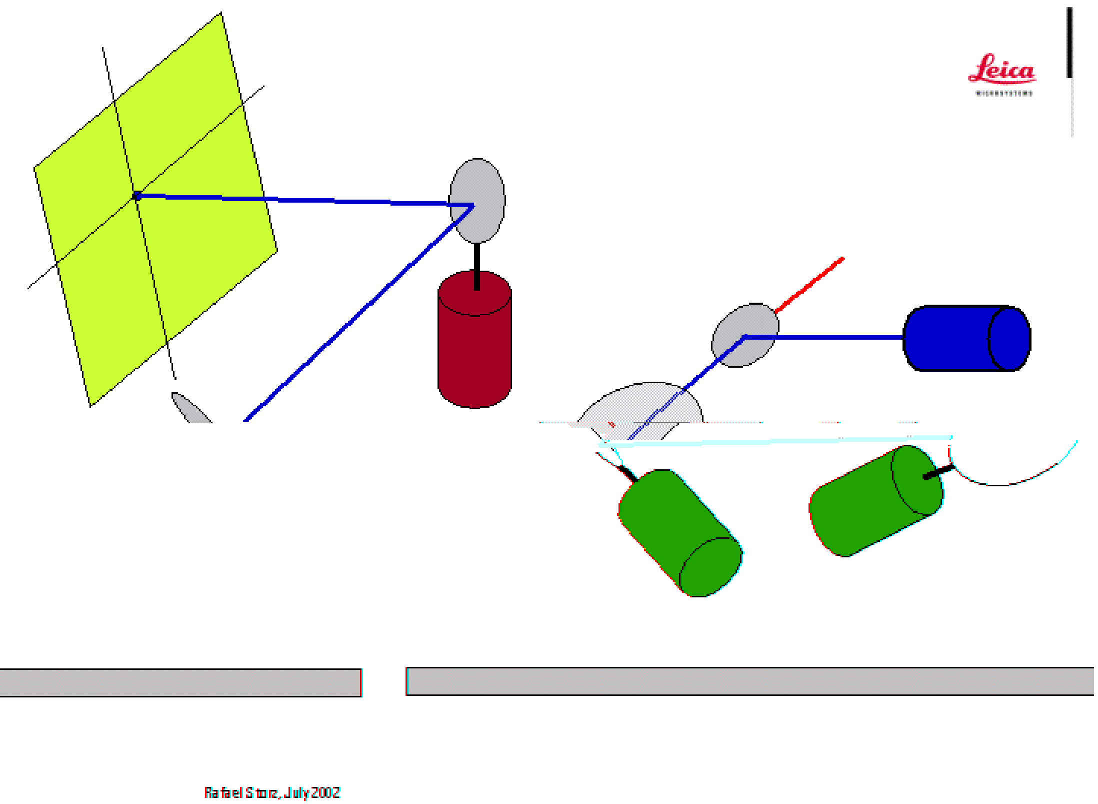
→ Locally photo-reorient liquid crystal

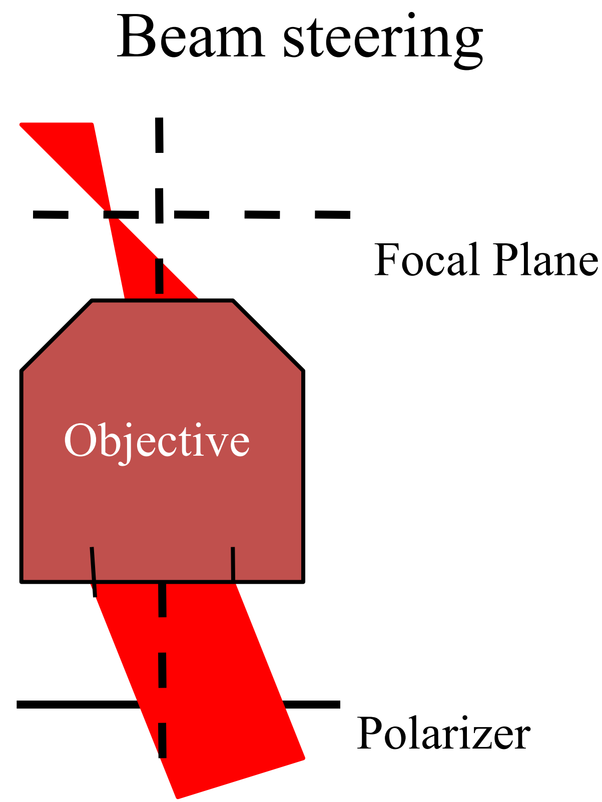


Applying and Aligning Monolayers



Beam steering of a focused beam





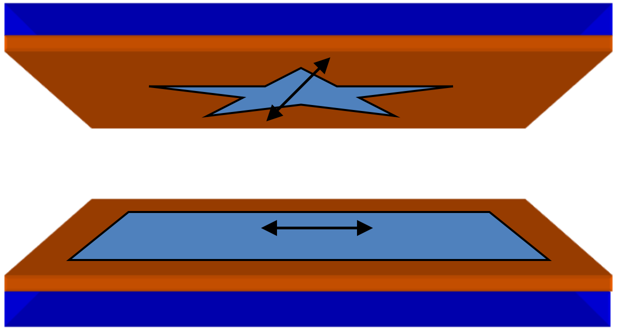
(1–10) *k*Hz

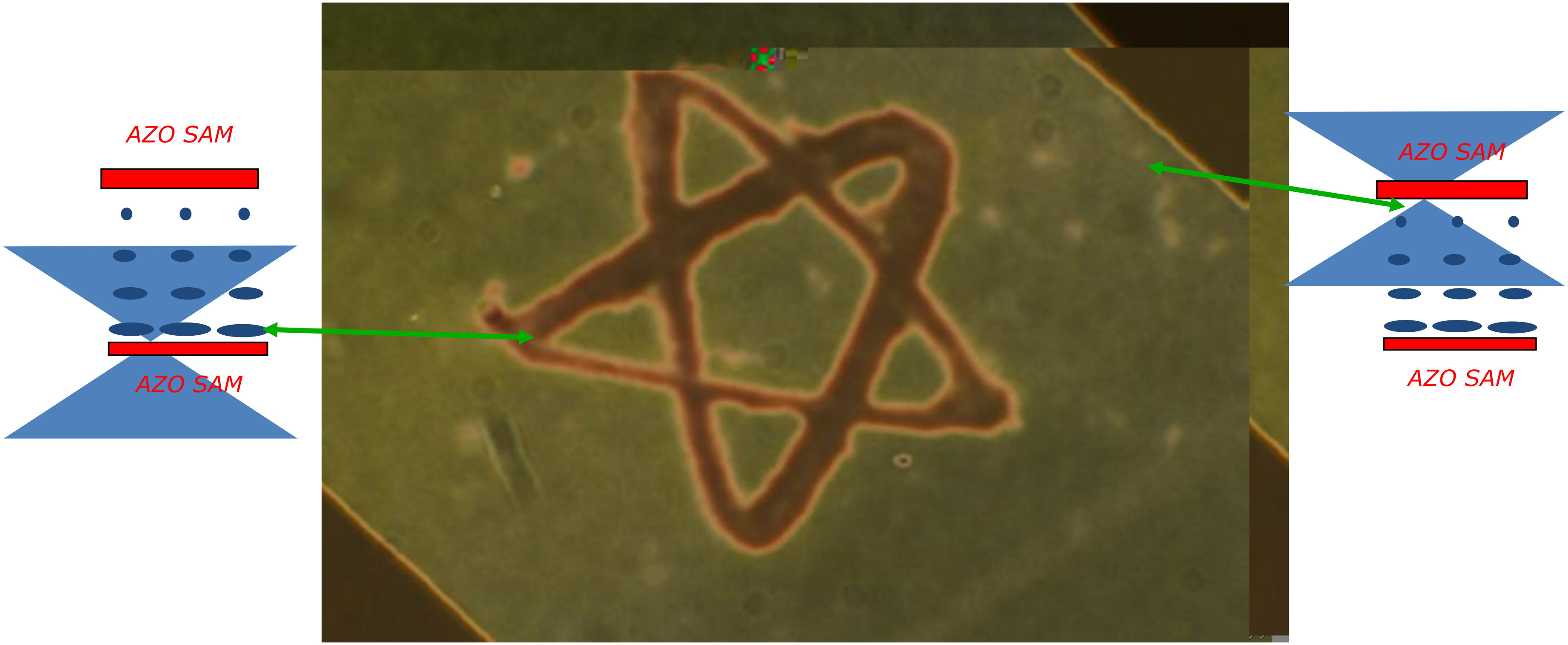
Equipment Used

- Laser power used ~.2 mW at objective
- λ = 488 nm

Create desired boundary conditions

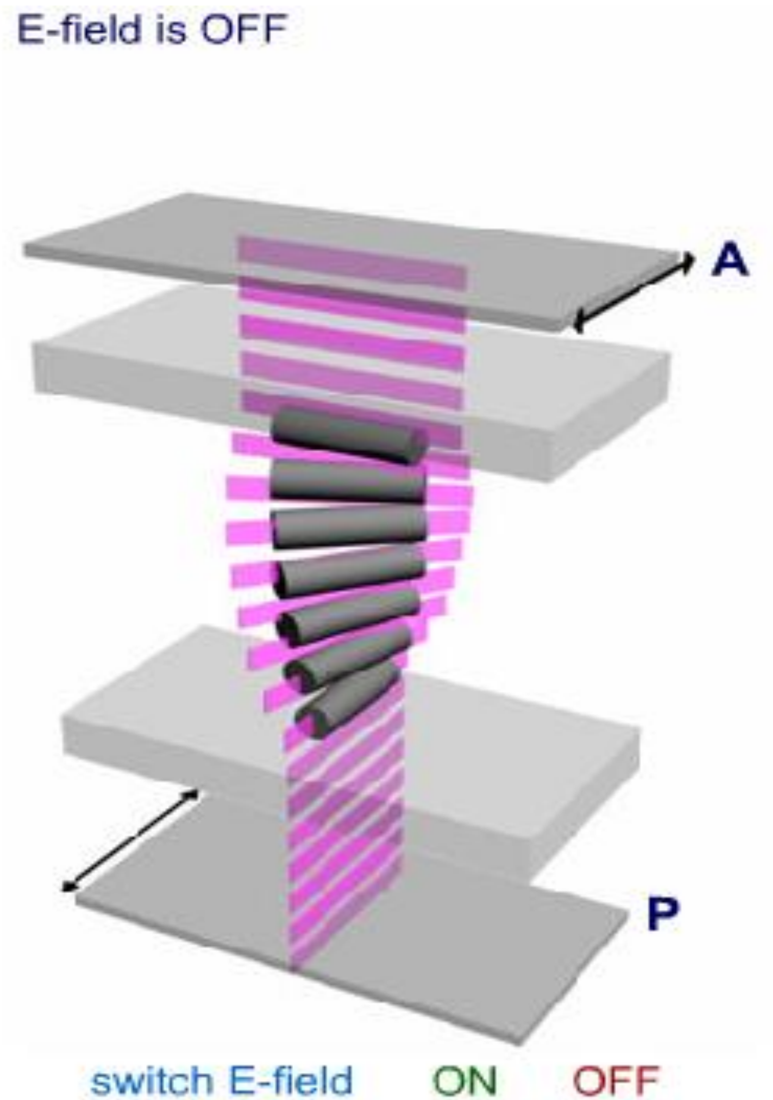
- Use confocal microscope to write on two slides to create desired boundary conditions.

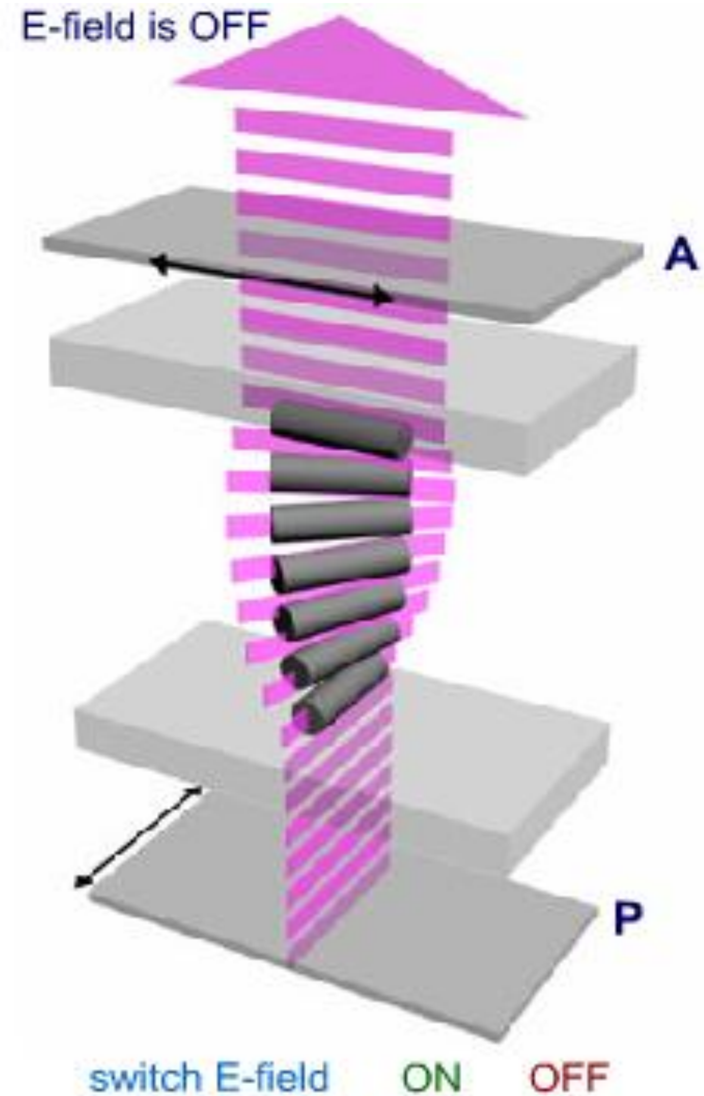




How Twisted Nematic Display Works?

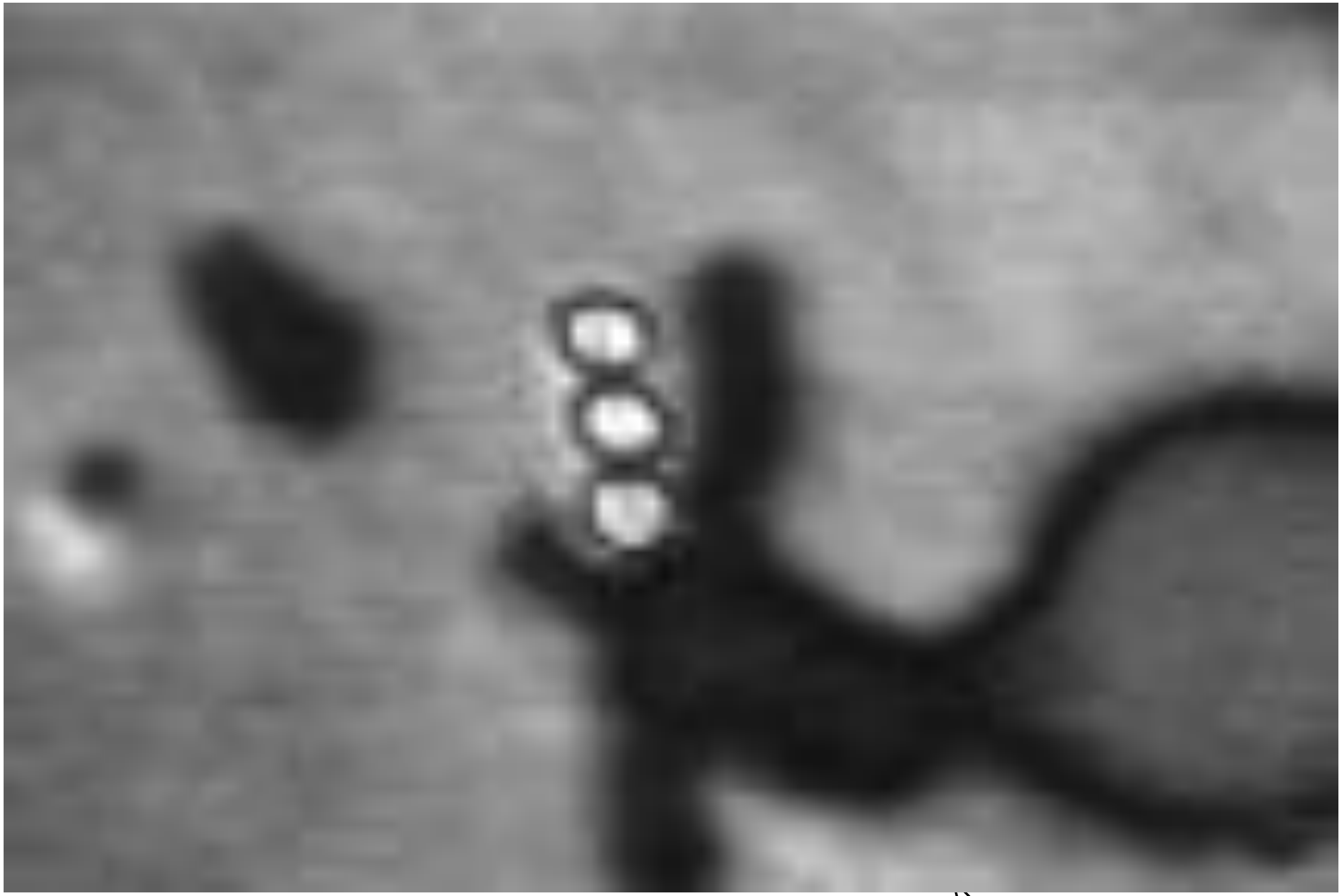
“Bright” state can correspond to field-on state and also to field-off state, depending on the design:



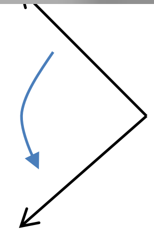


Note that two different polarization modes can be used

Rotation & Translation by laser polarization

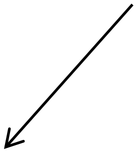


- Power ~ .2 mW
- Adjusted polarization by about 90°



Moving particles by realigning LCs

- Power ~ .2 mW
- Green area is uniformly aligned



Conclusions

•Monolayers provide yet another means of liquid crystal alignment.

•Monolayers affect the bulk of liquid crystal material by defining condition only at the surfaces.

•Dynamic alignment/realignment

•Monolayers used with tightly focused laser beams allow for creation of micro-scale patterns with increased resolution.

•Of interest for fundamental science – unlimited # of boundary conditions

•Particles and cluster movable at powers ~10-100 times smaller than those used in optical laser tweezers.

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