

# ME 517: Micro- and Nanoscale Processes

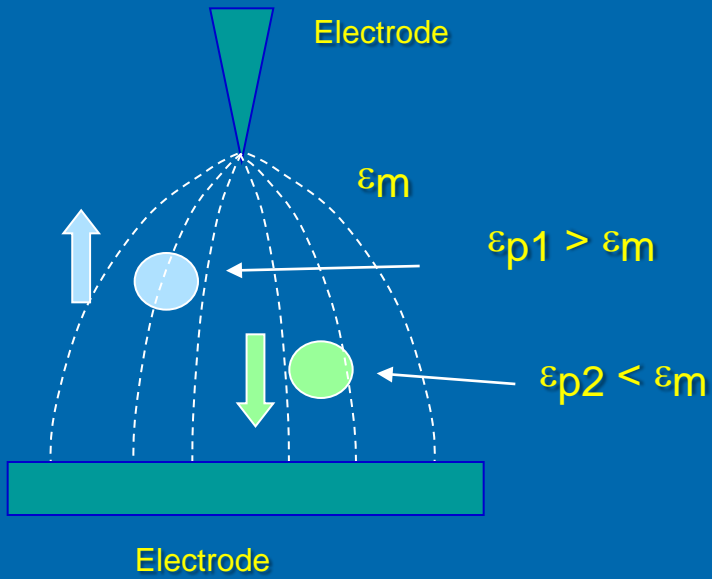
## Lecture 33: Electrokinetics - IV

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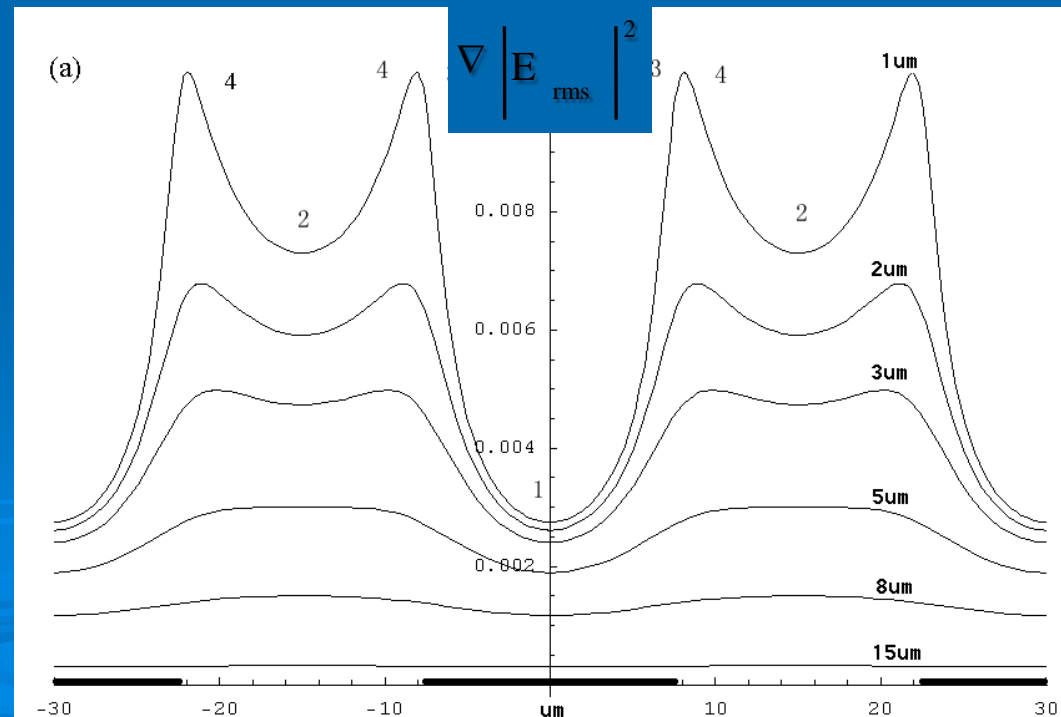
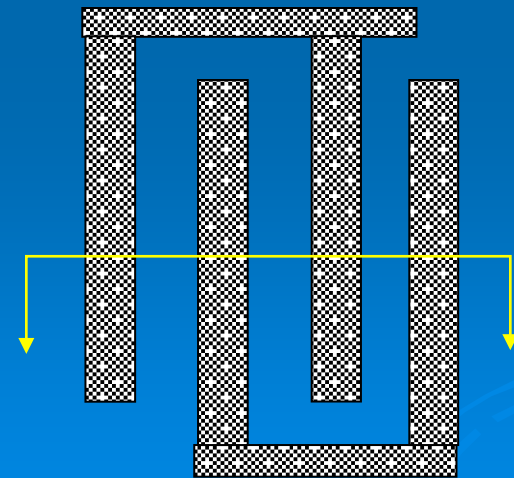
# Interdigitated Electrodes

H. Li, R. Bashir, *Sensors and Actuators B*



$$F = 2 \pi r^3 \epsilon_m \epsilon_0 \text{Re}[f_{\text{CM}}] \nabla \left| E_{\text{rms}} \right|^2$$

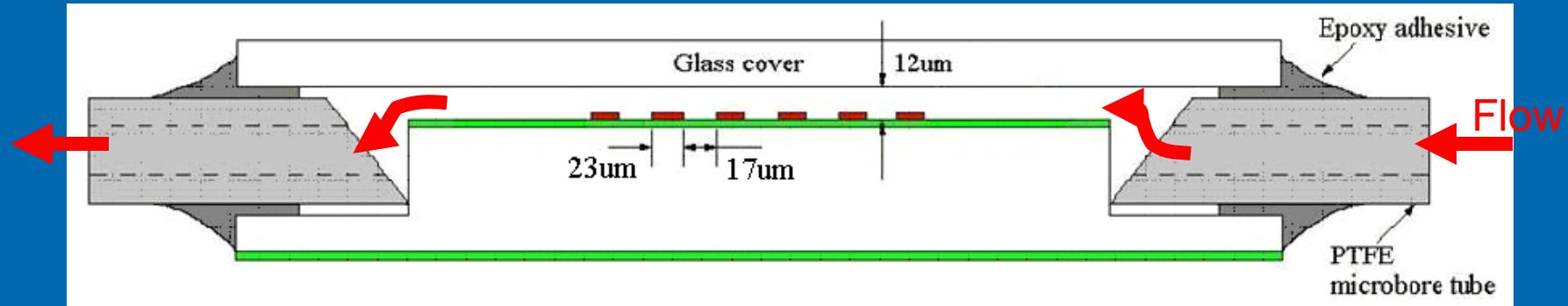
$$f_{\text{CM}}(\epsilon_p, \epsilon_m) = \frac{\epsilon_p - \epsilon_m}{\epsilon_p + 2\epsilon_m} \quad \epsilon_p = \epsilon(\omega)$$



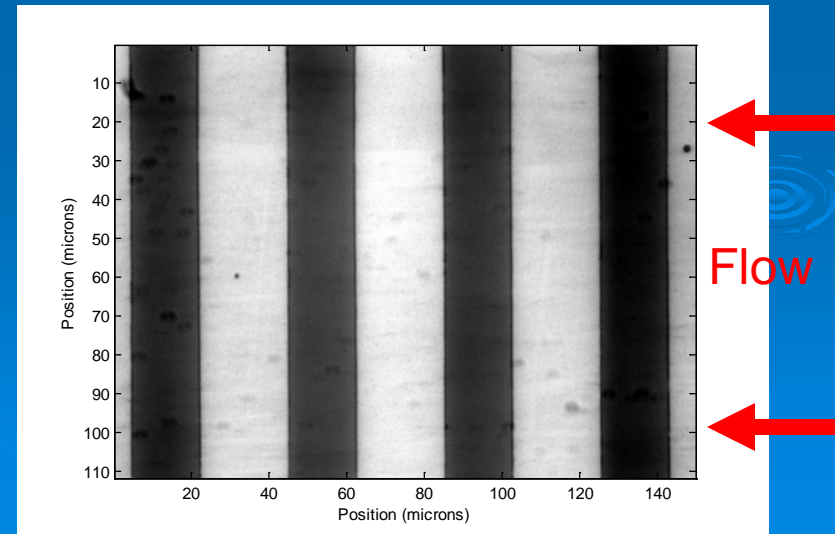
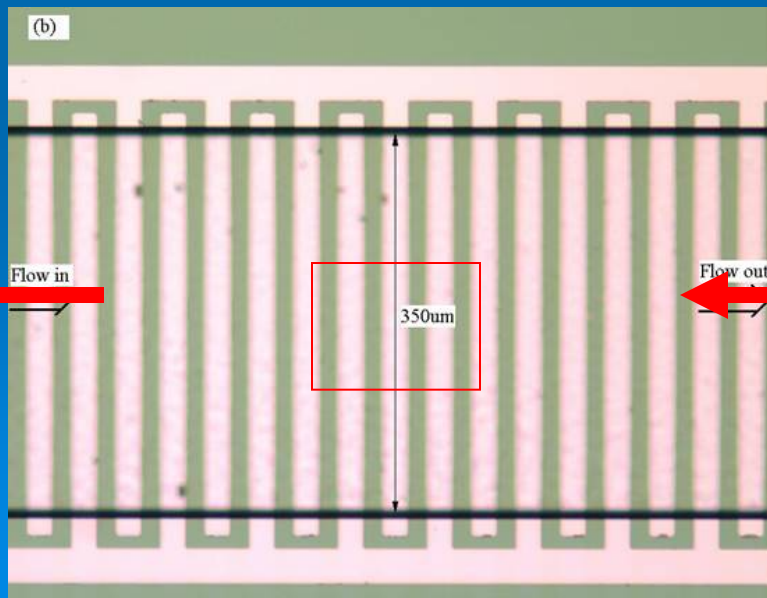
# Experimental Setup

Whitacre and Wereley, BioMEMS, 2007

Schematic of the device cross-section:



Photograph of the chamber (top view):

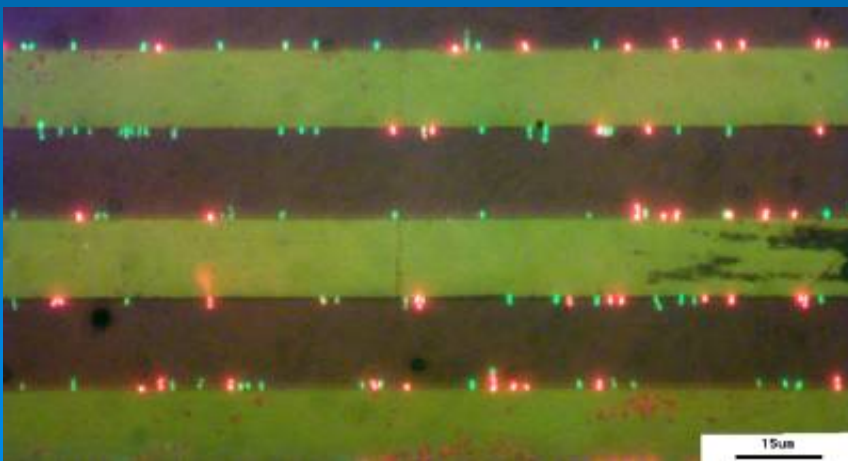


# Manipulation of *L. innocua*

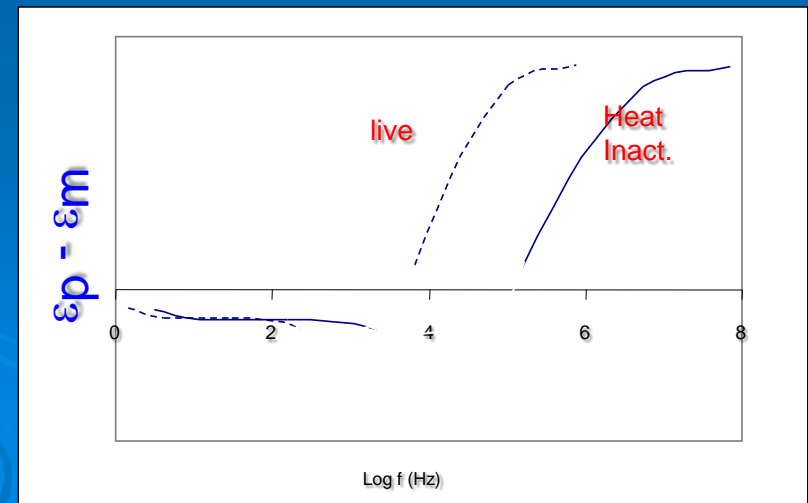
Negative DEP – AC voltage of 1V ( $V_{pp}$ ) and 1KHz



Positive DEP – AC voltage of 1V ( $V_{pp}$ ) and 100KHz



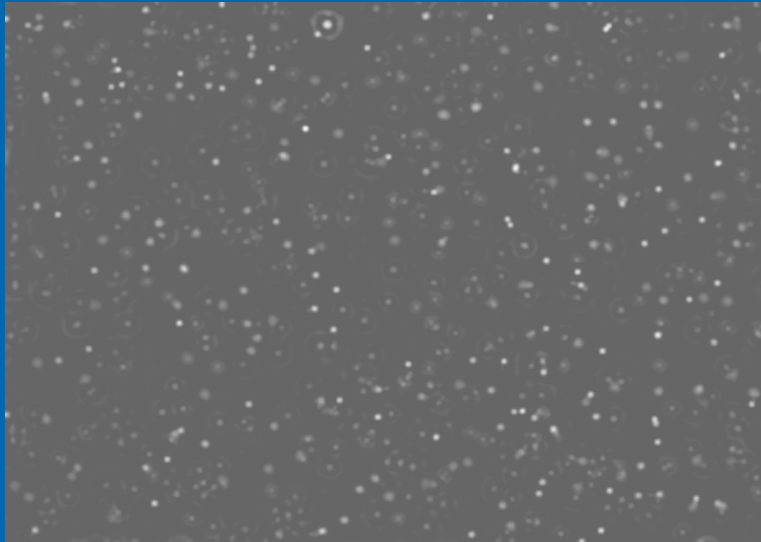
live cells (positive DEP), dead cells (negative DEP)  
1V ( $V_{pp}$ ) and 50KHz,



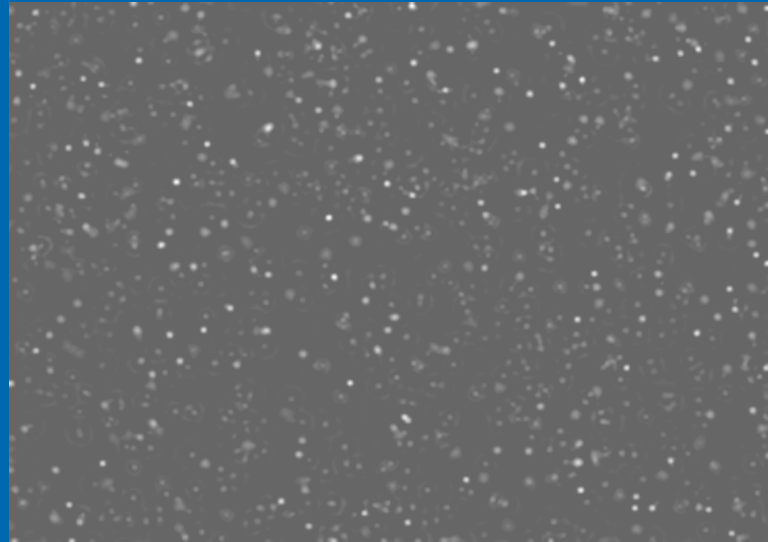
# Qualitative DEP Results

60x objective, 0.69  $\mu\text{m}$  particles, DOF $\sim$ 3  $\mu\text{m}$

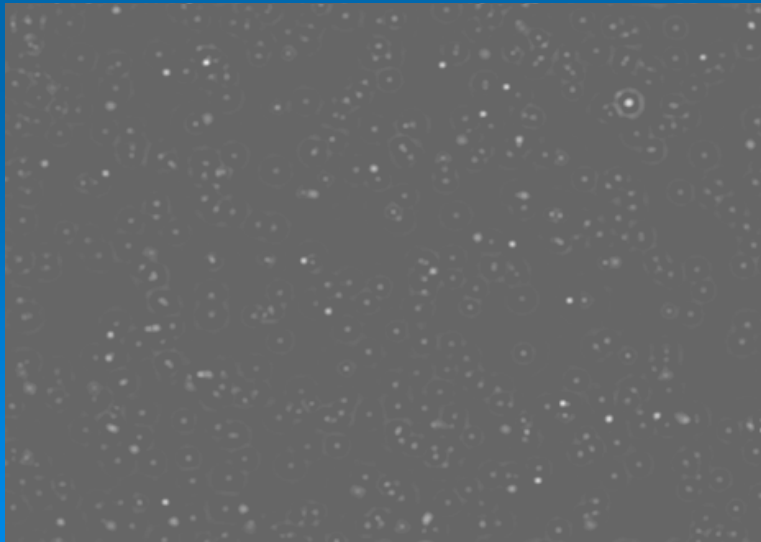
0.5V



2.0V



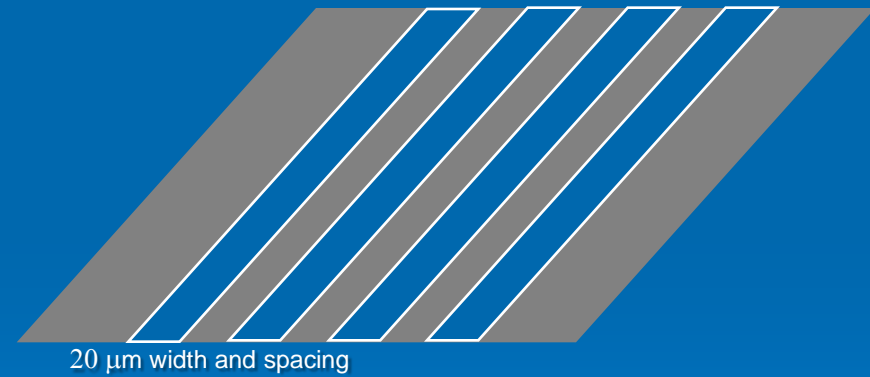
2.5V



4.0V



# DEP Manipulation Schemes (nDEP)

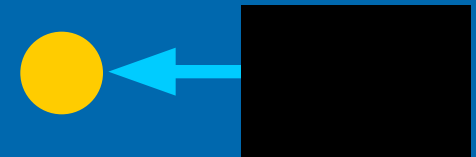


- Not Connected
- +V
- V
- 

3D arrangement  
2D arrangement



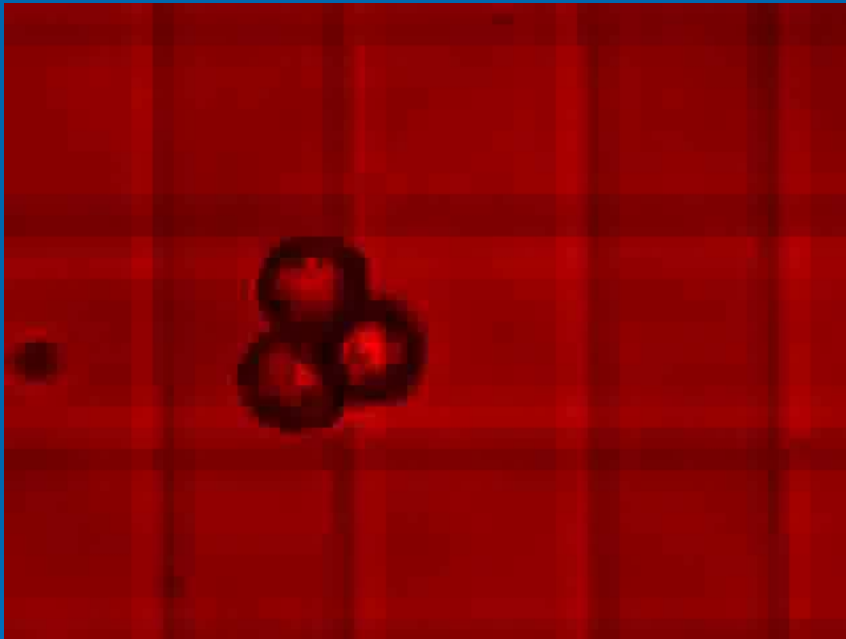
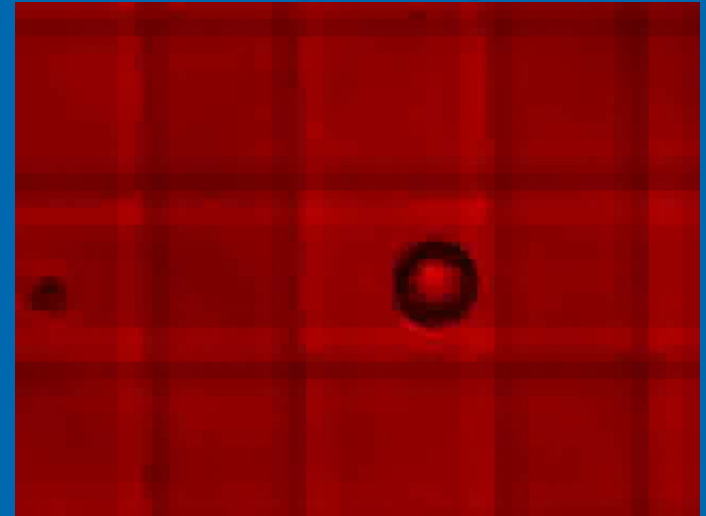
2-step ~~1-step~~  
translation



SIDE VIEW

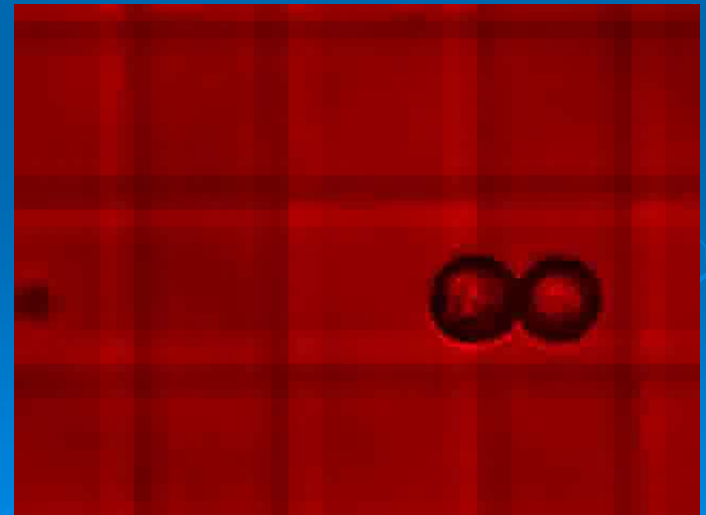
# DEP Trapping Results (3D)

$T = 2.0 \text{ sec}$   
 $13 V_{pk-pk}$



$T = 0.5 \text{ sec}$   
 $20 V_{pk-pk}$

$T = 1.0 \text{ sec}$   
 $15 V_{pk-pk}$



[Movie Link 1](#)  
[Movie Link 2](#)  
[Movie Link 3](#)

# Optical Interaction with Electrodes

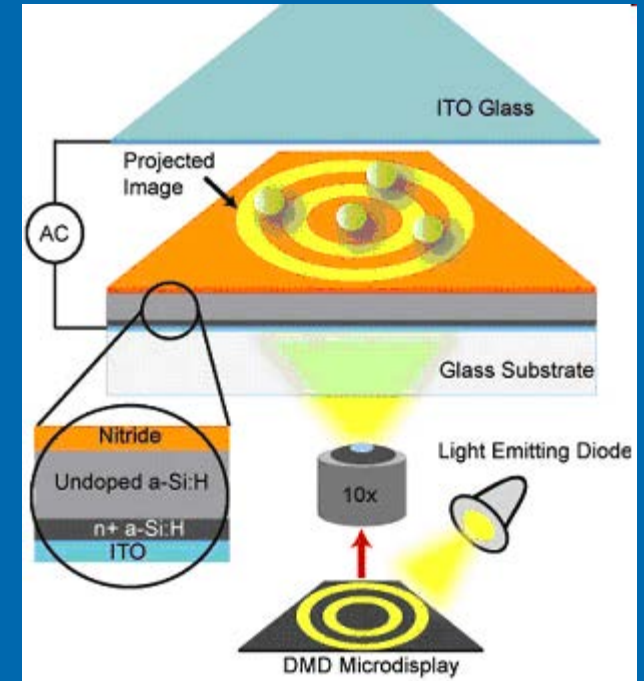
- Opto-electric tweezers (OET)
  - DEP with dynamically definable electrodes
- Rapid electrokinetic patterning (REP)
  - Electrothermal fluid flow plus particle polarization





# Optoelectronic Tweezers (OET)

- Couple illumination with photosensitive materials (a:Si) to generate non-uniform electric fields
  - Dielectrophoresis
  - ACEO
- REP differs:
  - Uniform electric field
  - Polarization mechanisms
  - Greater fluid conductivity\*



Chiou, P.Y., et al., *Nature* (2005)

