Field-induced Characteristics of nanoparticles with Applications to Thin Film Displays

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Outline:

Introduction to Electrorheological effect

Display from electrorheological suspension

Paperlike thermochromic display

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Electrorheological effect

What is ER suspension ?

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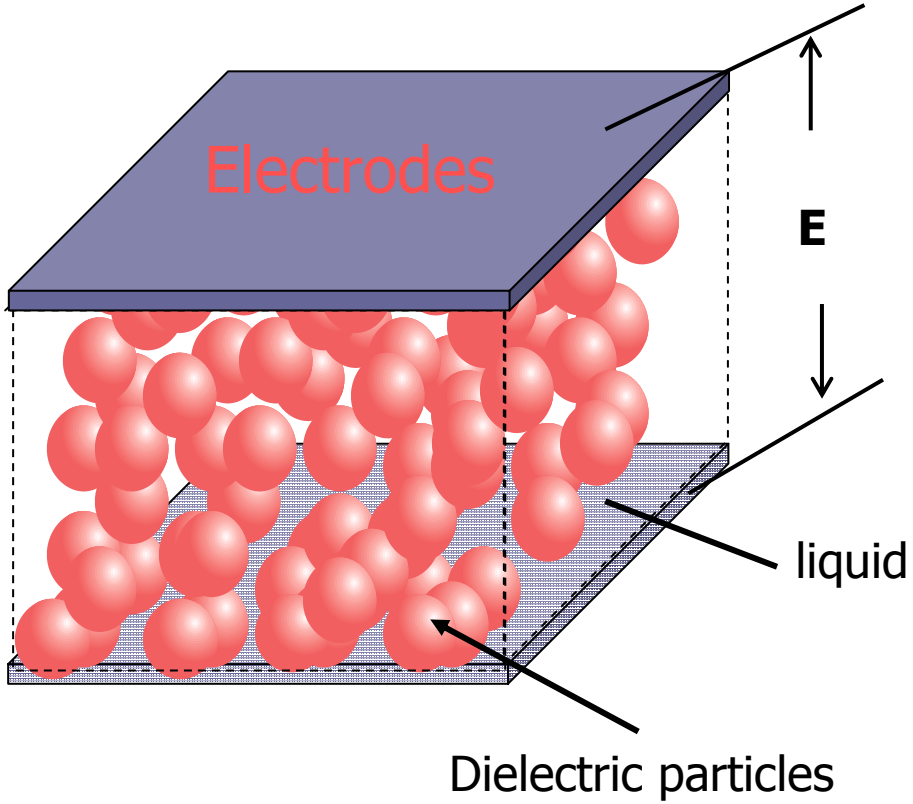

ER fluid is a kind of colloid consisting of dielectric particles suspended in a nonconducting liquid. It can change from liquid state to solid state abruptly.

Mechanism of ER effect

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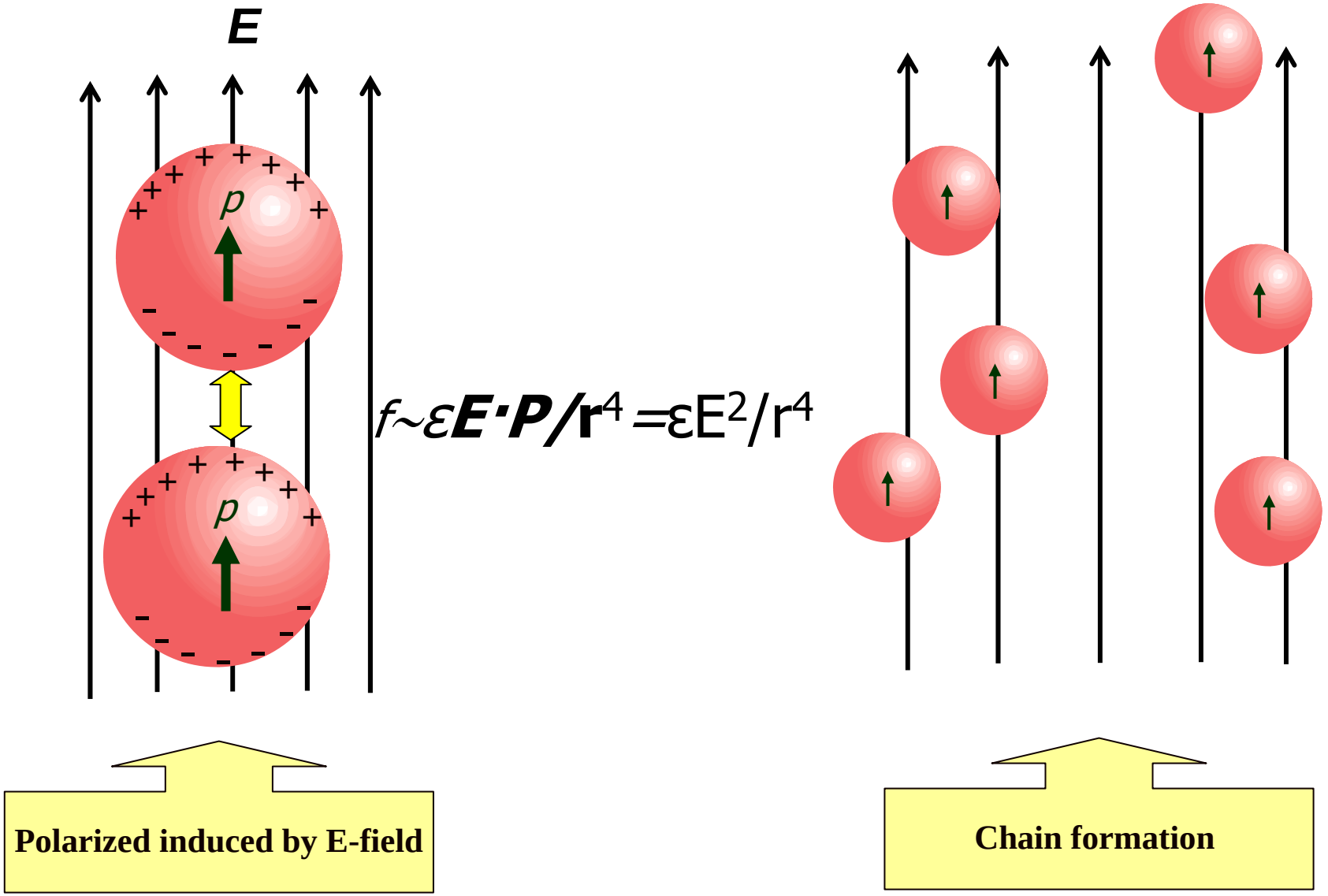
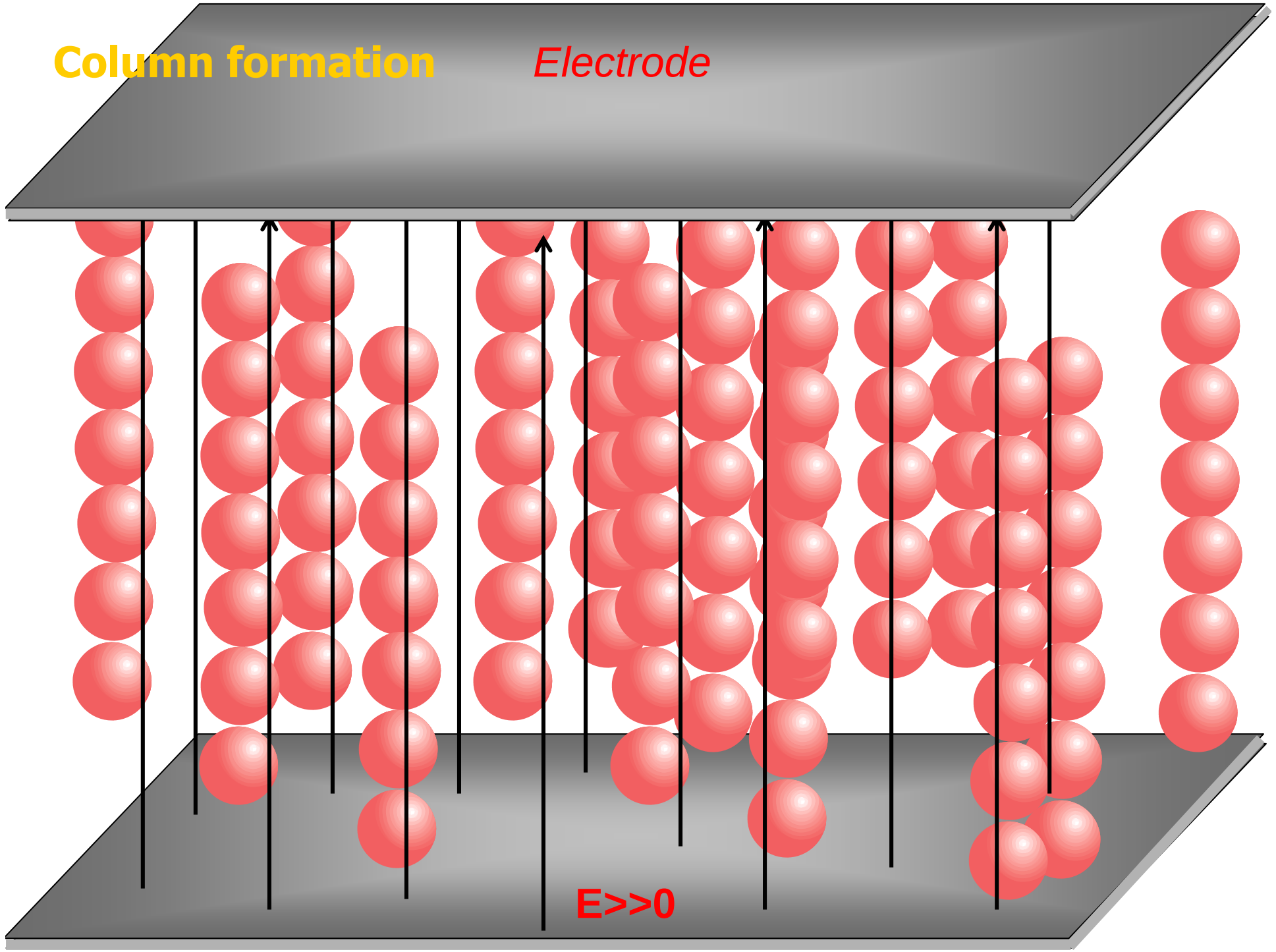
dipole-dipole interaction model




Column formation
Electrode
E>>0

Electrorheological forces

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Attraction

Structural evolution of ER suspension under an external electric field

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E=0

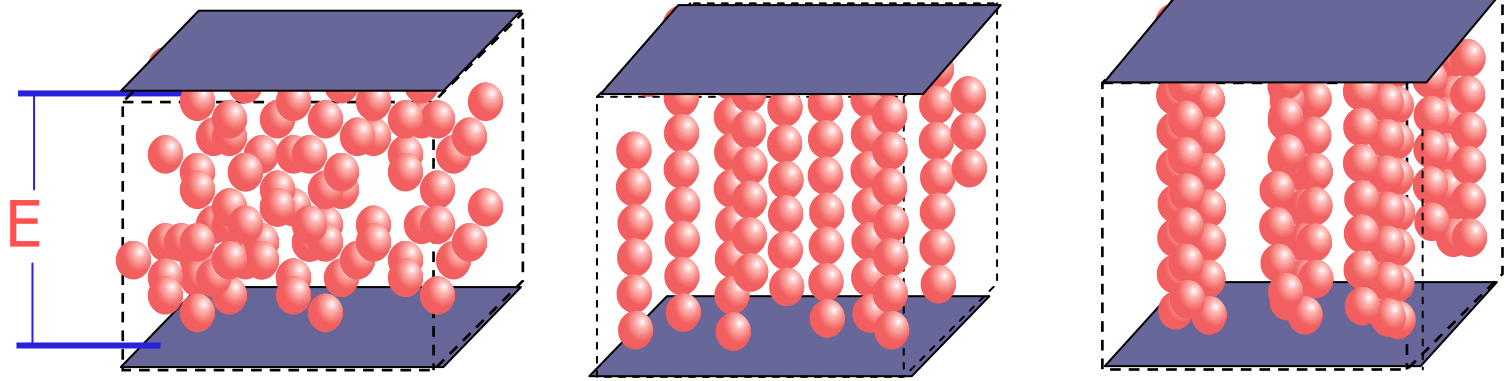
Random distribution

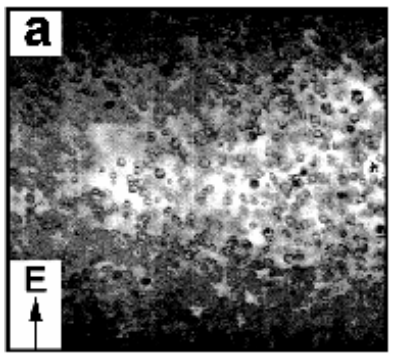
E>0

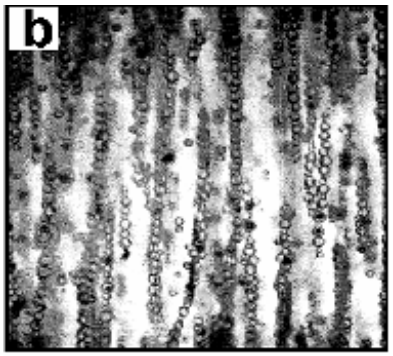
Form chains

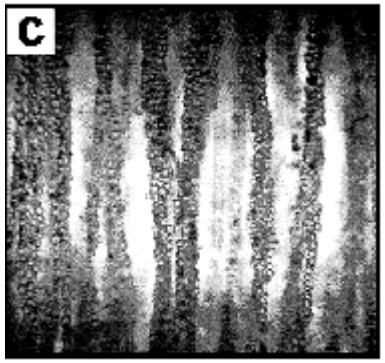
E>>0

Form columns









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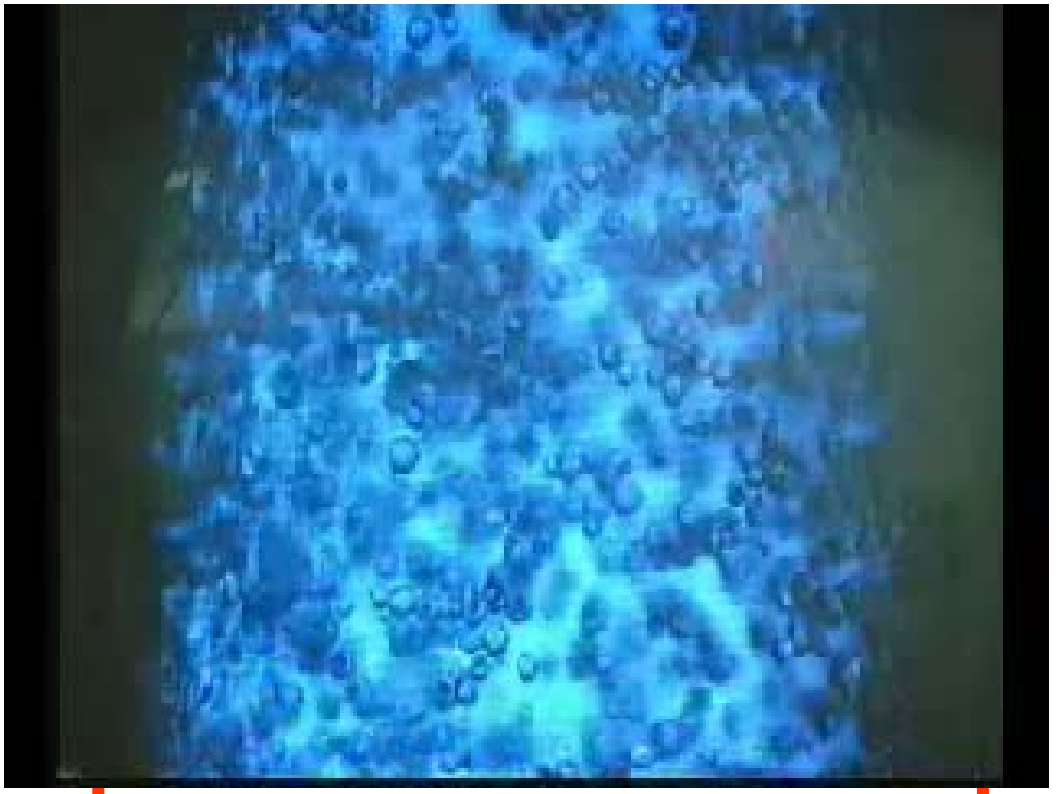

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Display from electrorheological suspension

Display principle

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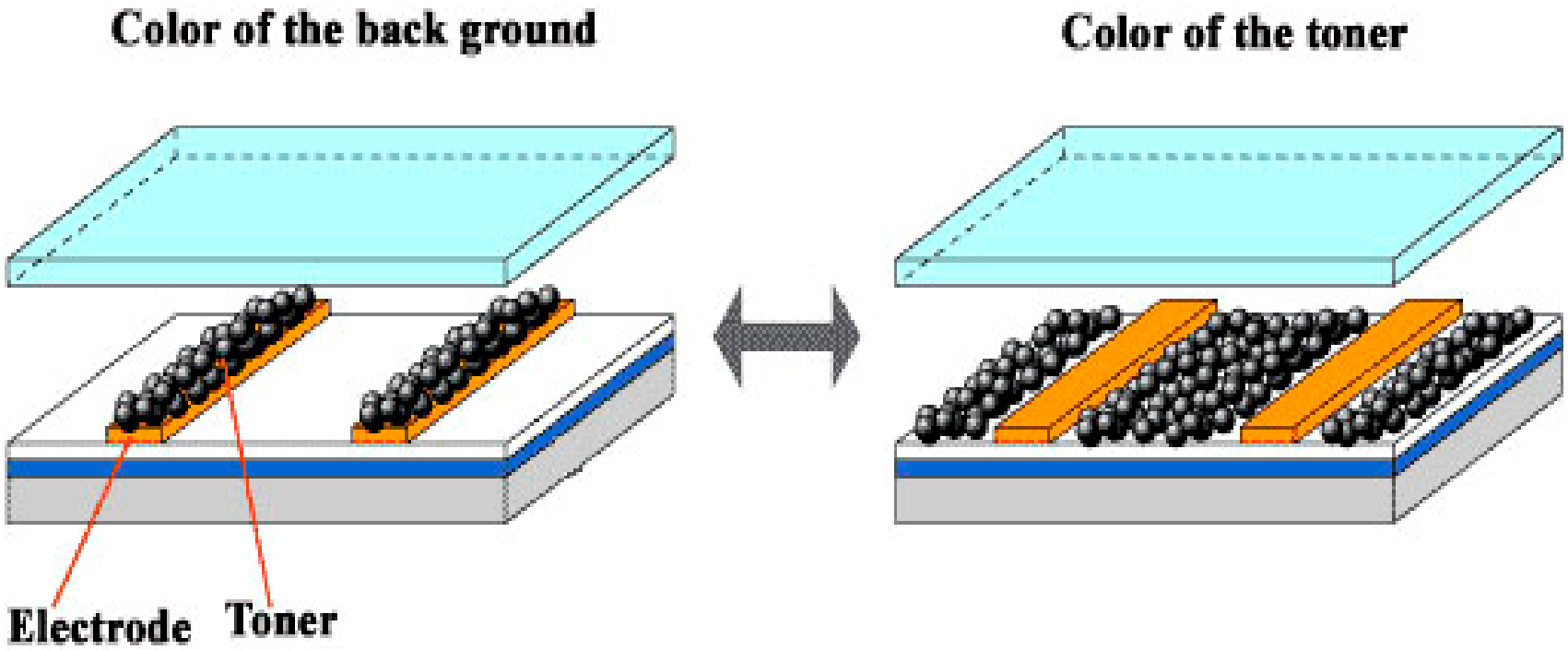

Nanoparticles used for display

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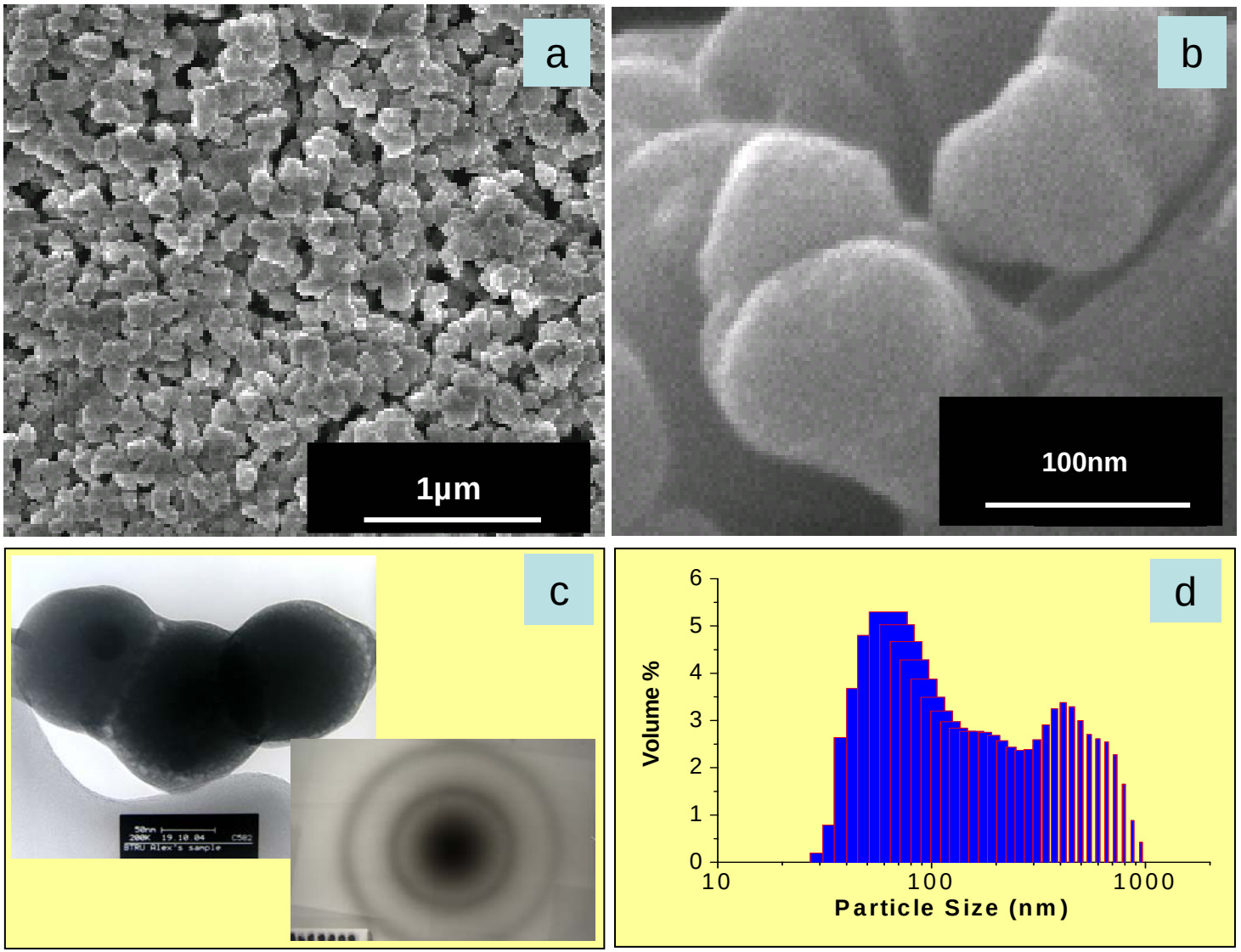

Illustration of the mechanism for the storage mode display

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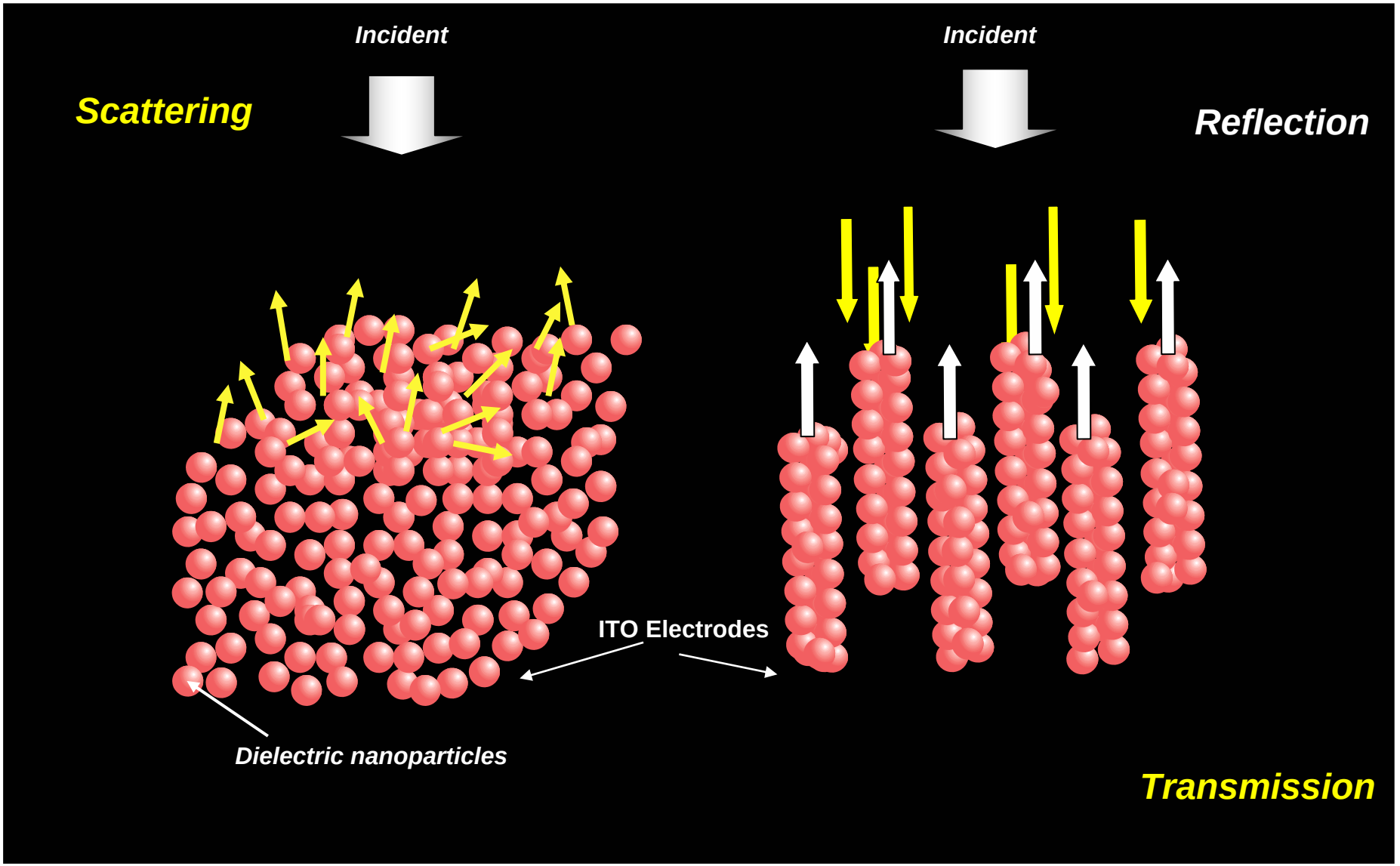
left and right panels show the cases without and with applied electric field, respectively



Top-views of field-induced patterns formed by nanoparticles

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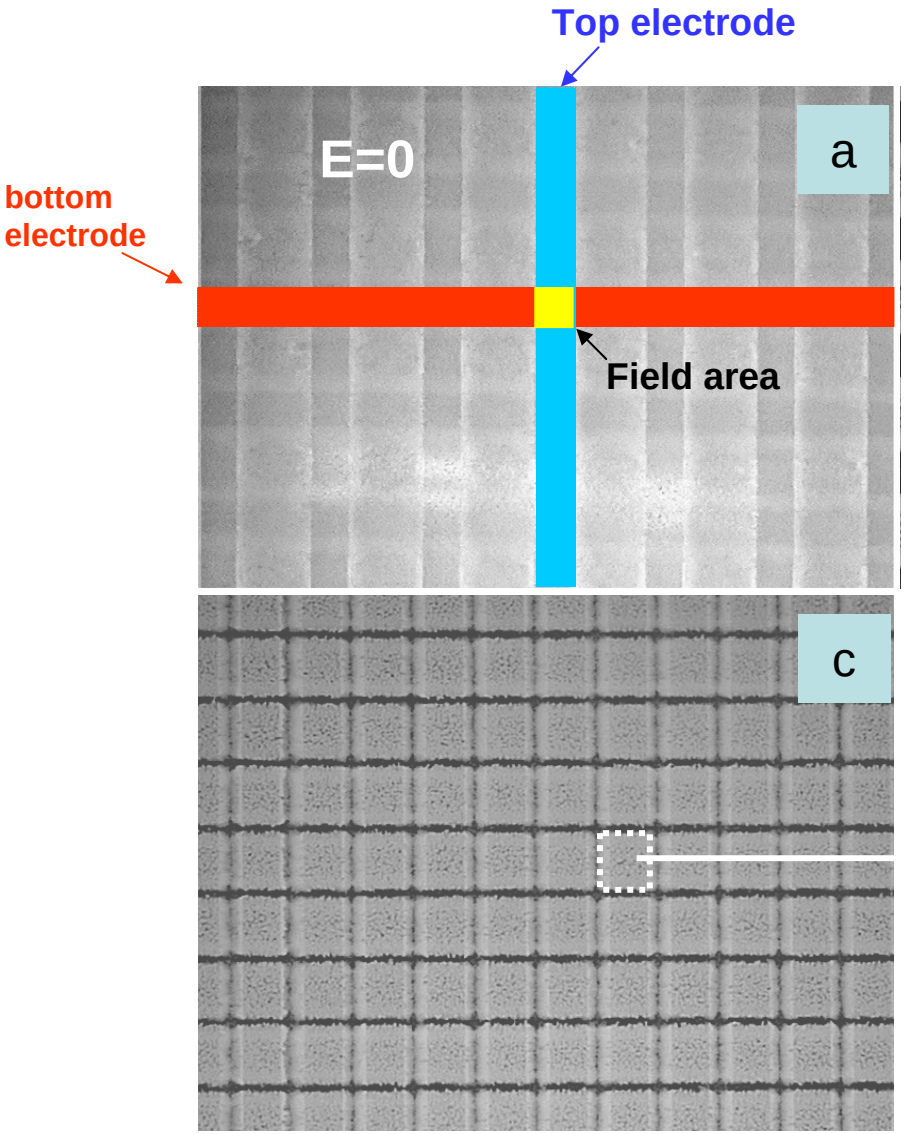

Pattern formation with different electrode configurations

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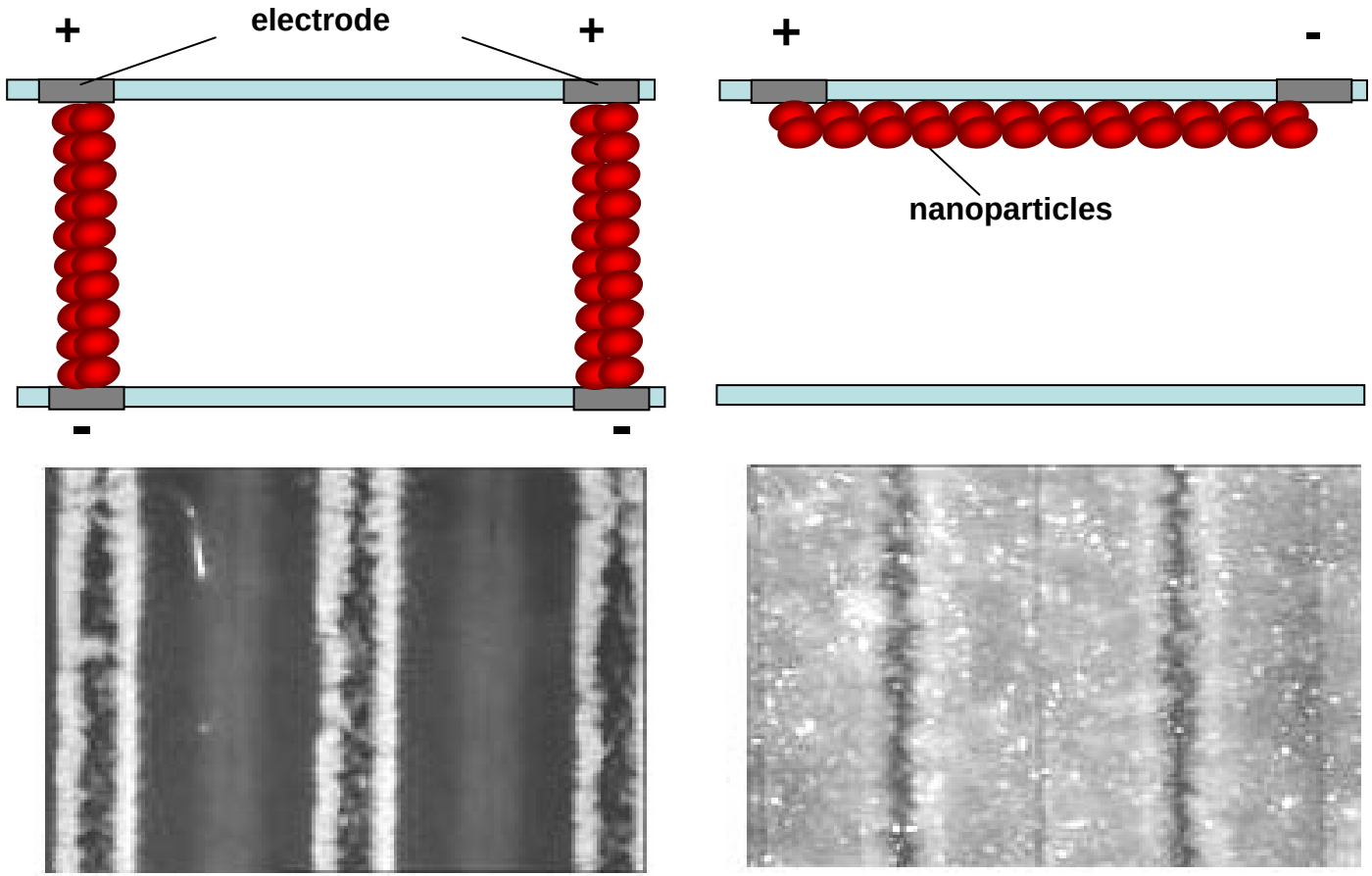
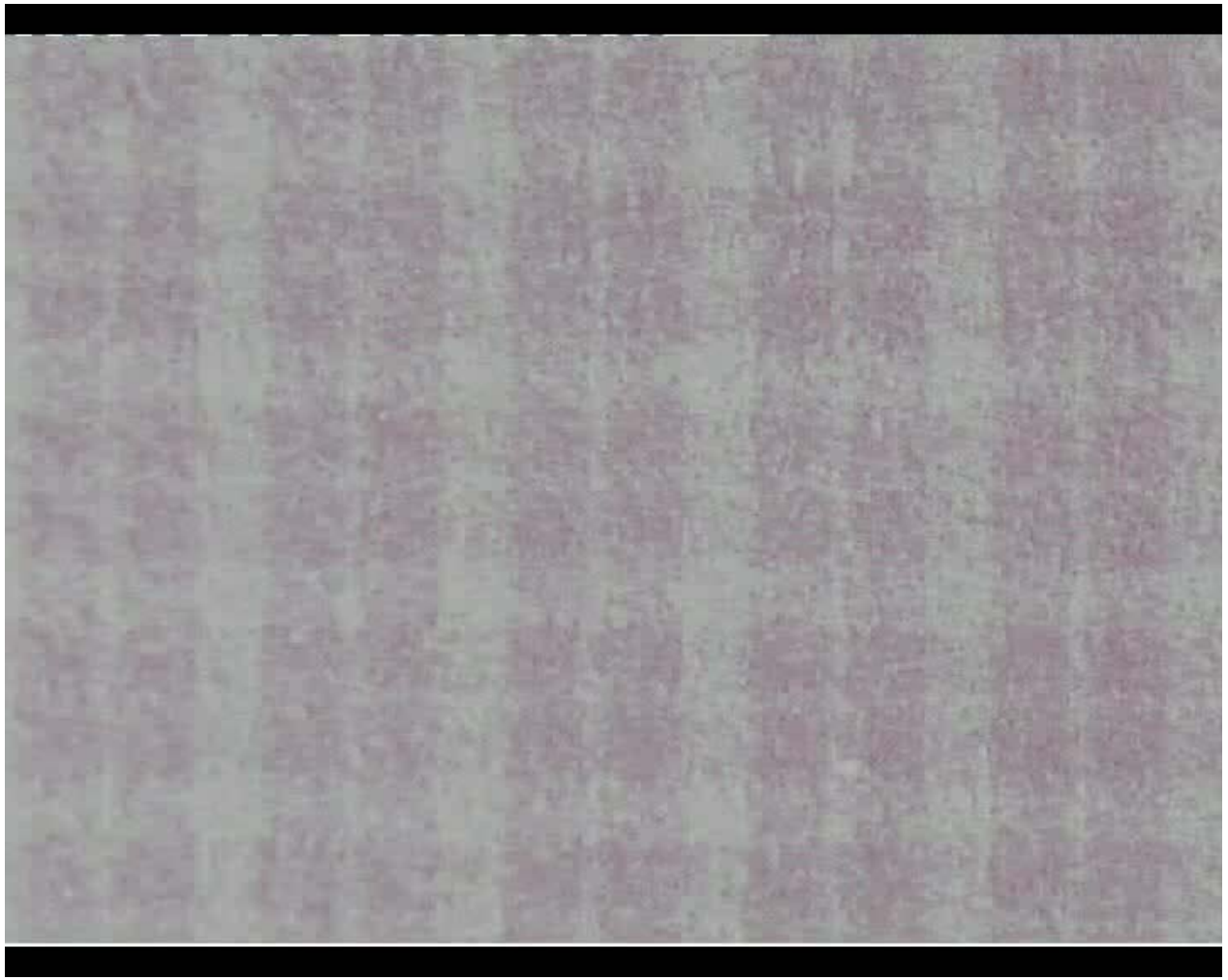


Electric field is applied across the top and bottom electrodes



Electric field formed by the planar electrodes

Optical transmission characteristics of nanoparticle-based suspension at different field strengths

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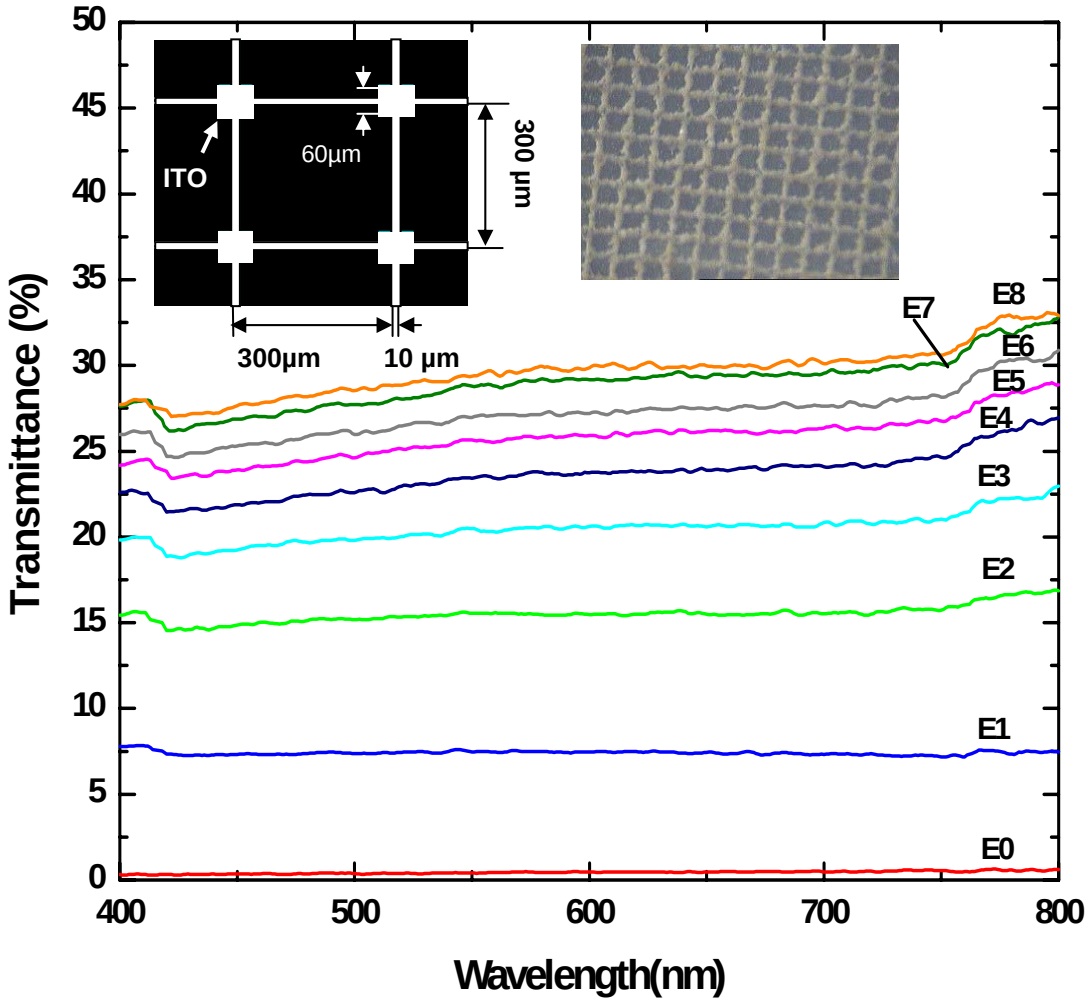

Images viewed through the display panel

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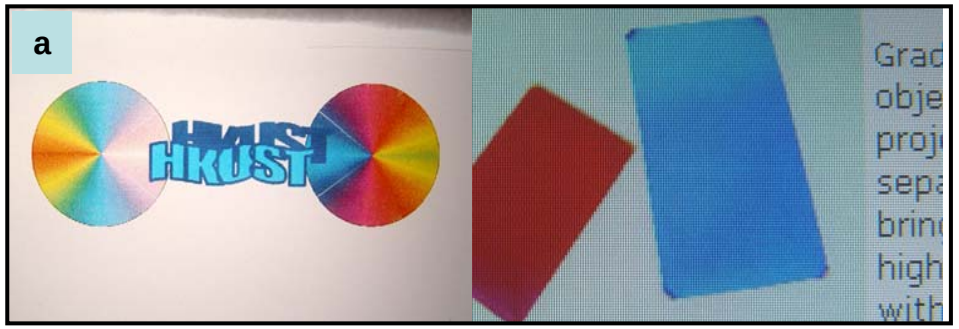
Display panel

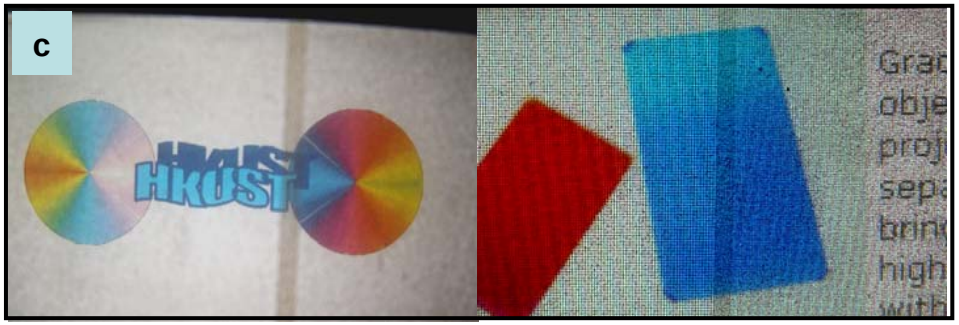
Original color panel

Viewed through the display panel



Without electric field

With electric field



Display panels formed with different backgrounds

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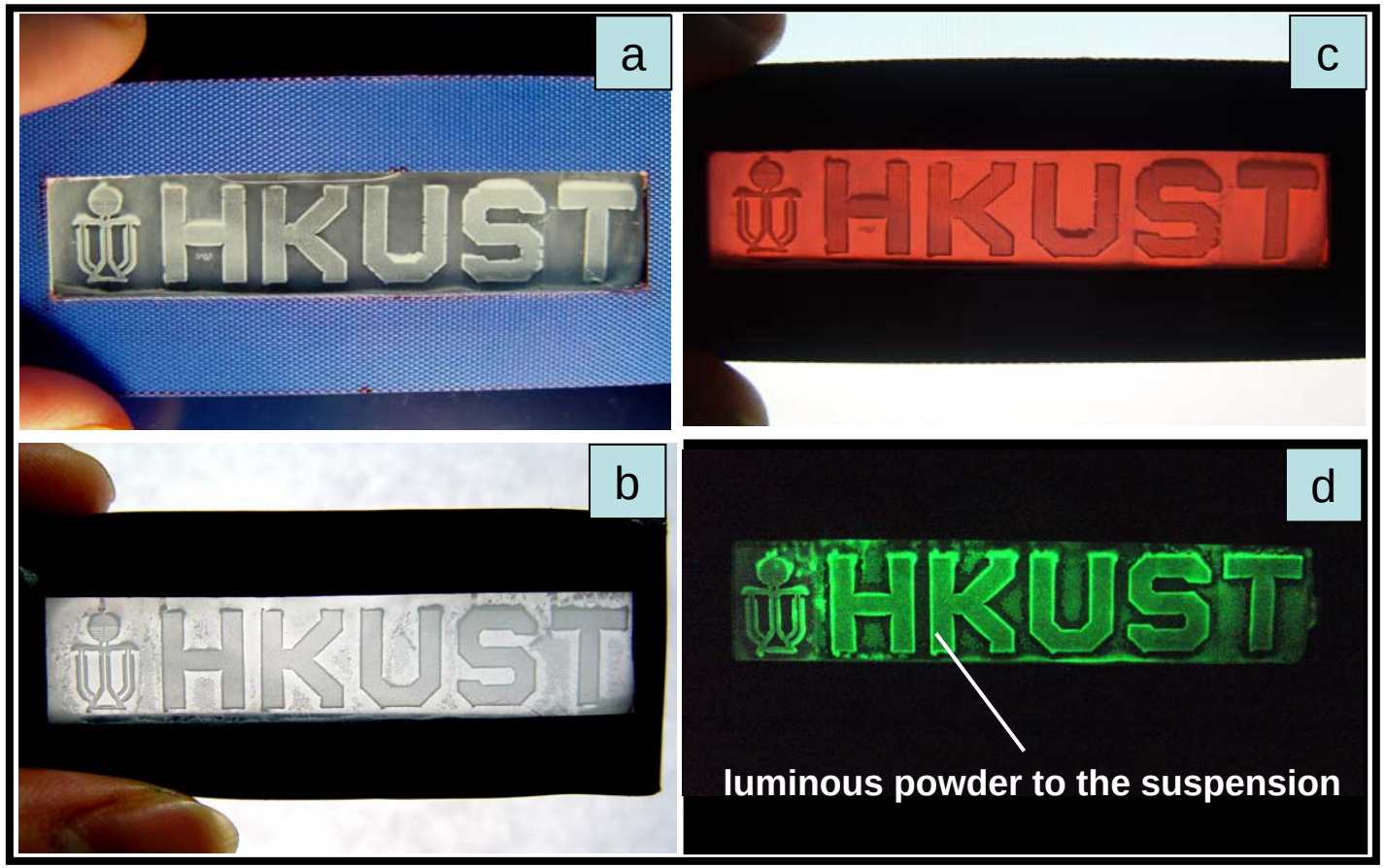
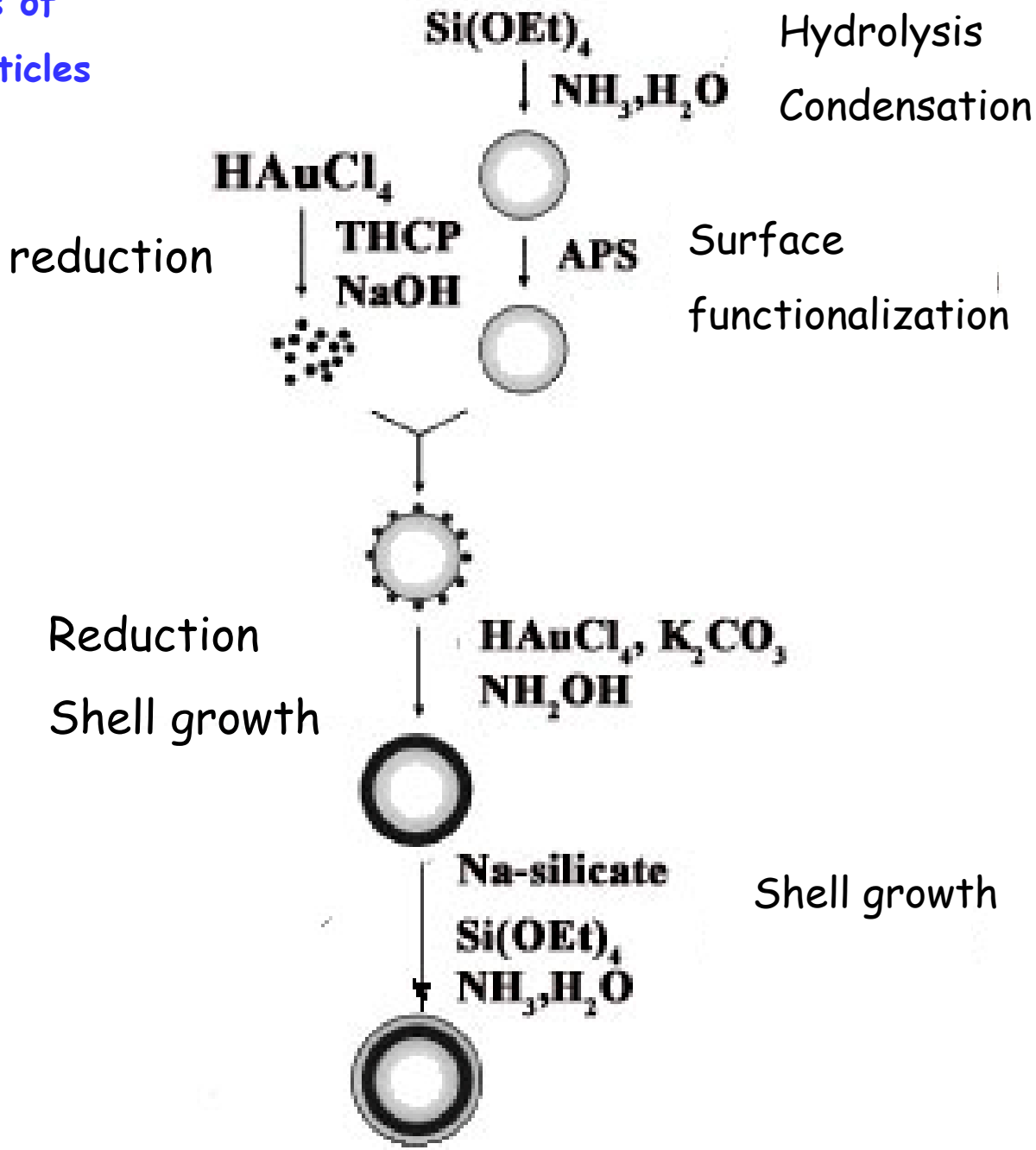
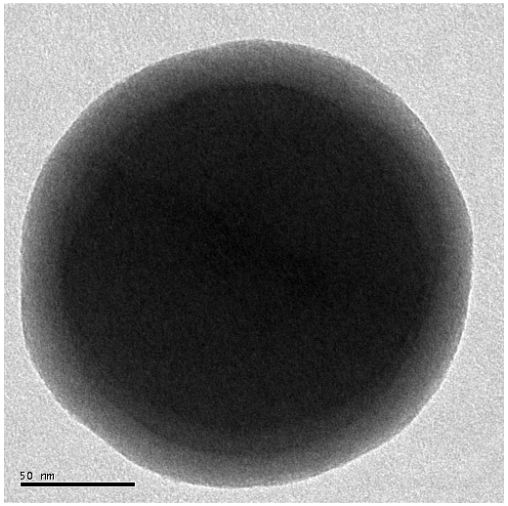


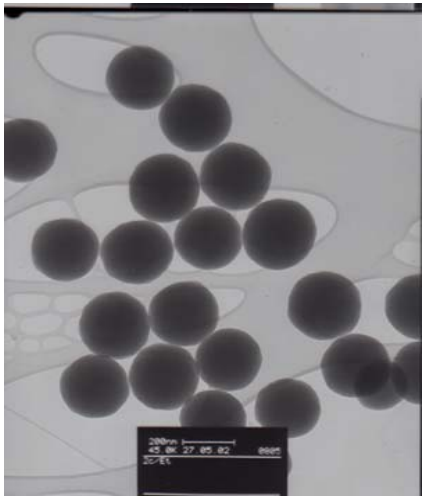
The drawback of nanoparticle-based ER display presented above is the classic tendency of particles to agglomerate together irreversibly, the flocculation effect.

Diagram of the synthesis of silica core-gold shell particles

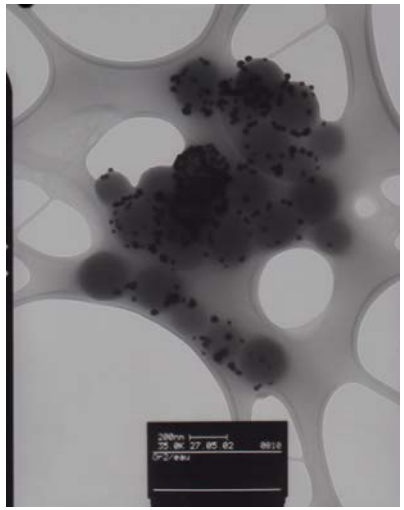


Results: particle shapes by TEM





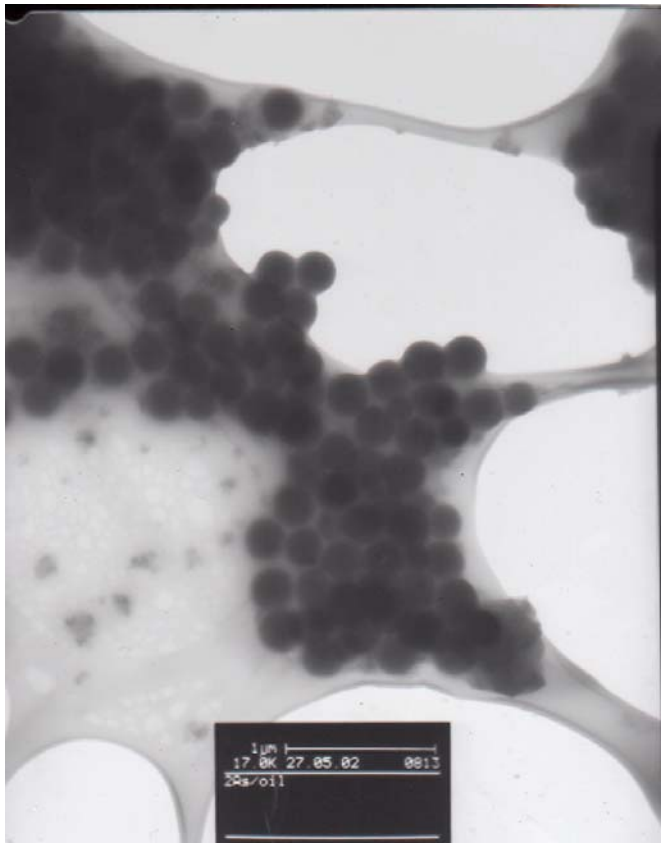
Dyed particles



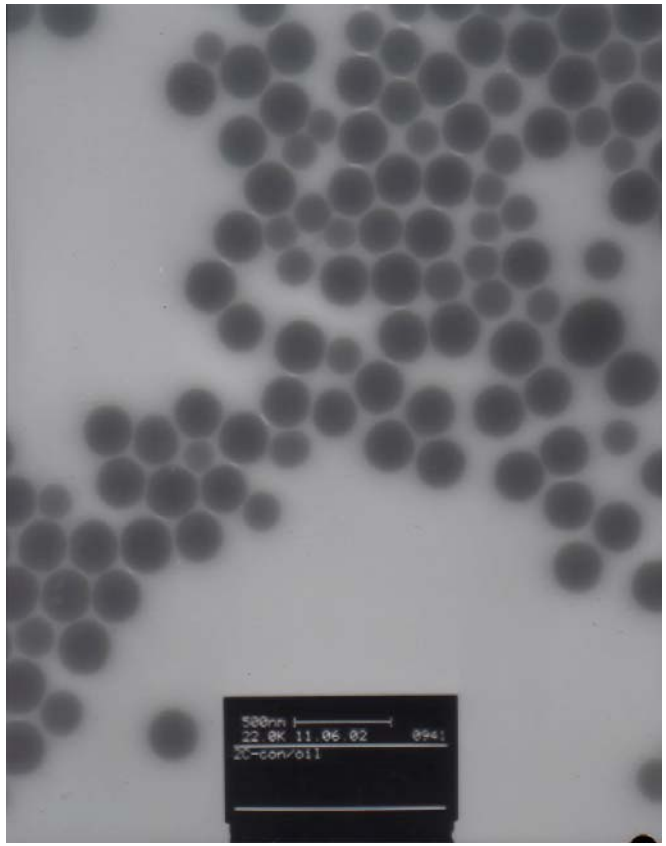
Gold shell

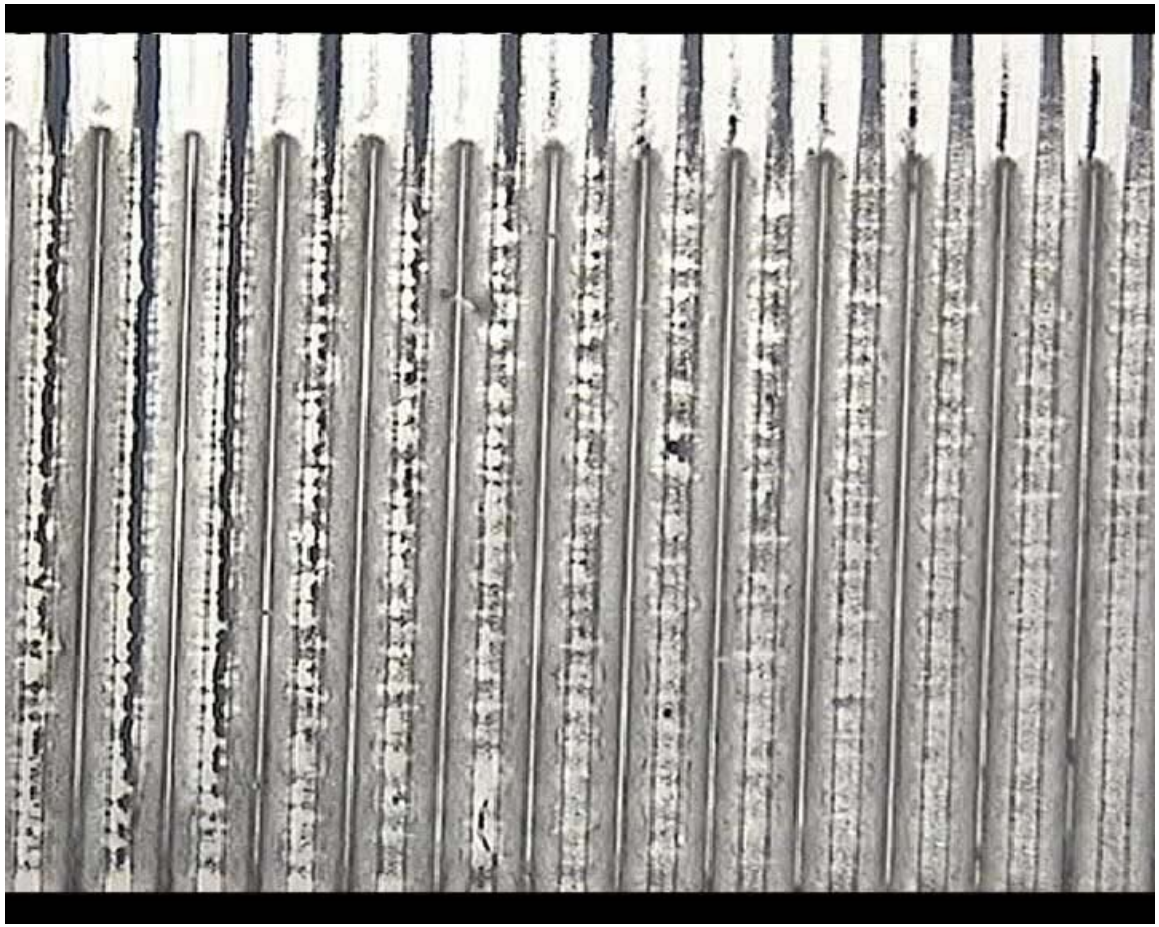
Dispersion in oil

2As



2C





Paperlike thermochromic display

Polydimethylsioxane (PDMS)-based conducting composite

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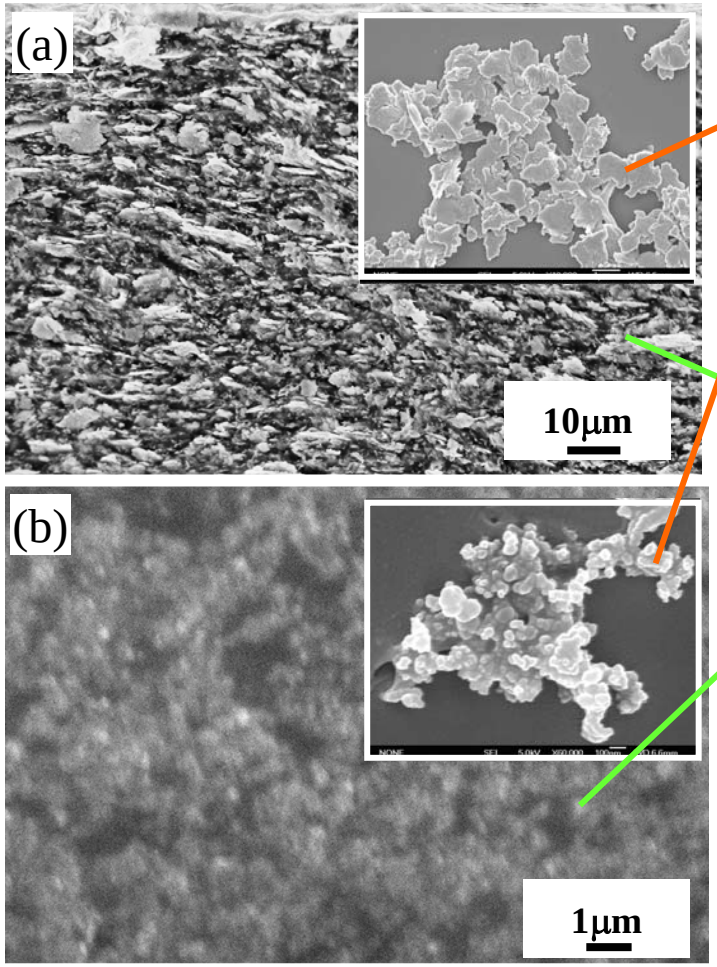

Nano or micro-conducting particles

PDMS + conducting particles

SEM pictures of the cured conductive composite and powders:
(a) Ag+PDMS (84wt%); (b) C+PDMS 28wt%

Electrode fabricated with PDMS/Carbon conducting composite

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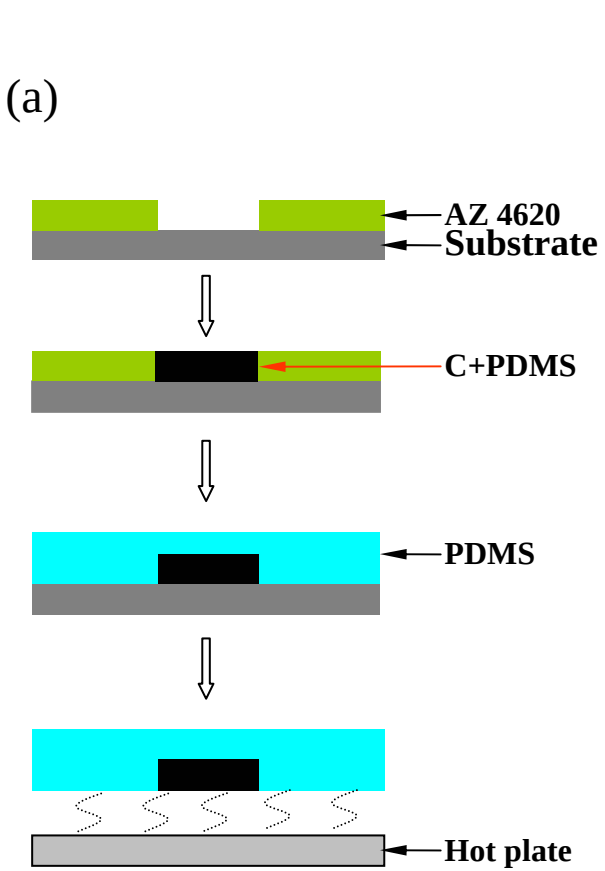

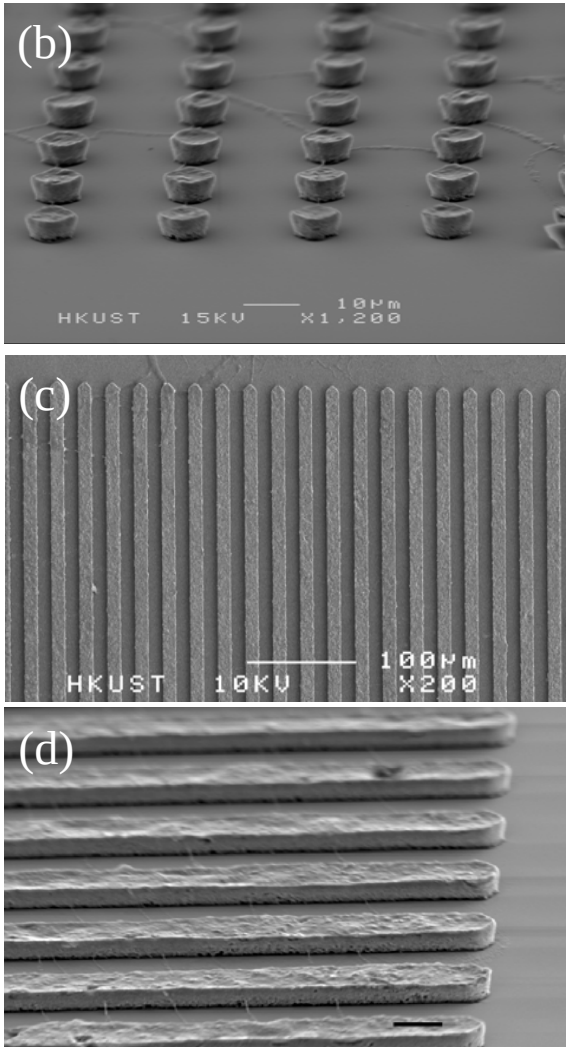

Process flow chart illustrating the patterning of conductive PDMS by soft lithography. (a) Micro-patterning of the conductive PDMS, (b) –(d) SEM pictures showing the various fabricated conductive patterns.

Electrode fabricated with PDMS/Silver conducting composite

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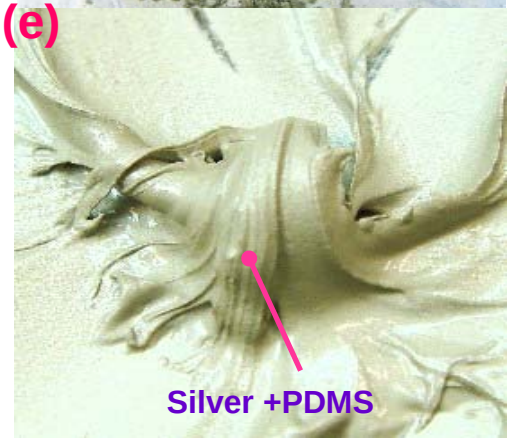
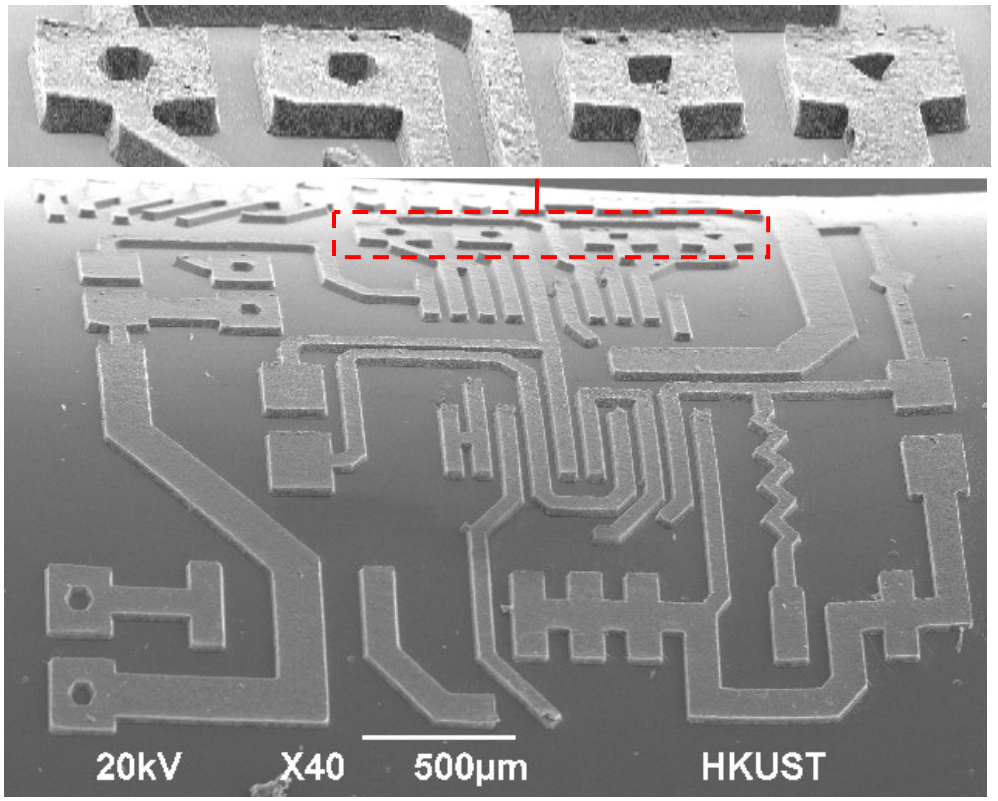
(d)

(e)





Micro-heater from PDMS conducting composite

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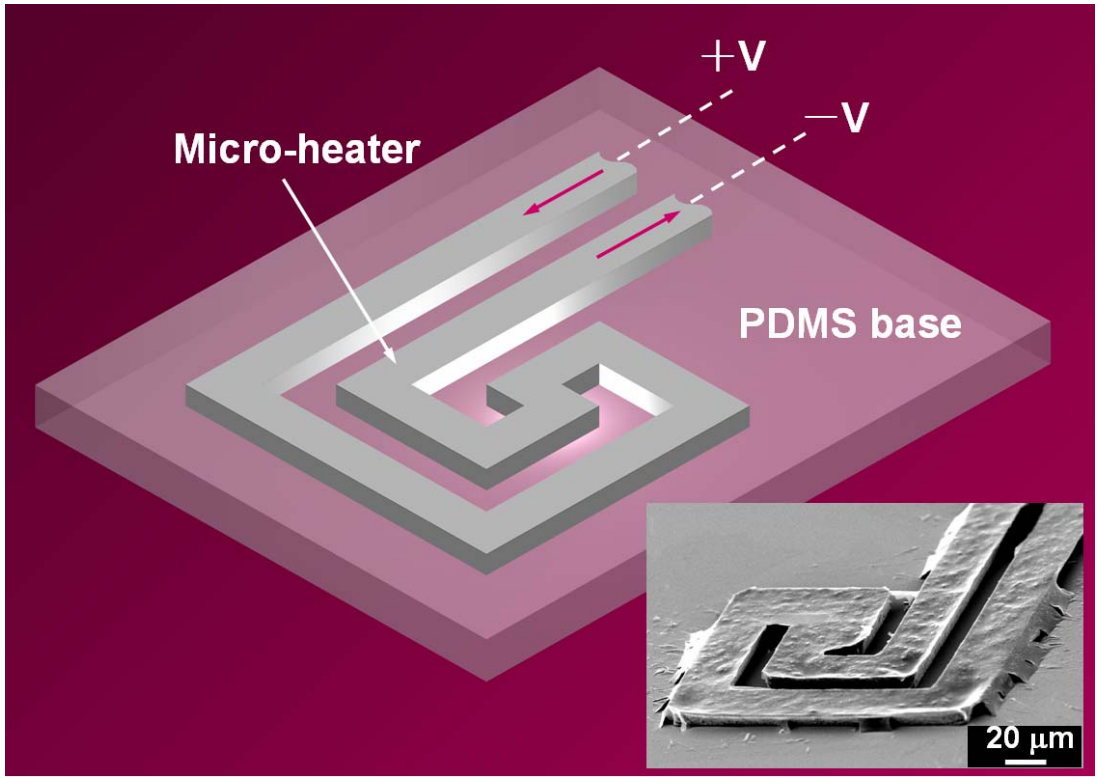

Schematic illustration of the micro-heater. The three-dimensional helical-patterned structure is made from silver micro-particles-PDMS composite. Inset: a SEM picture of the micro-heater whose line width is 25

Temperature of the micro-heater's central heating part plotted as a function of the input voltage.

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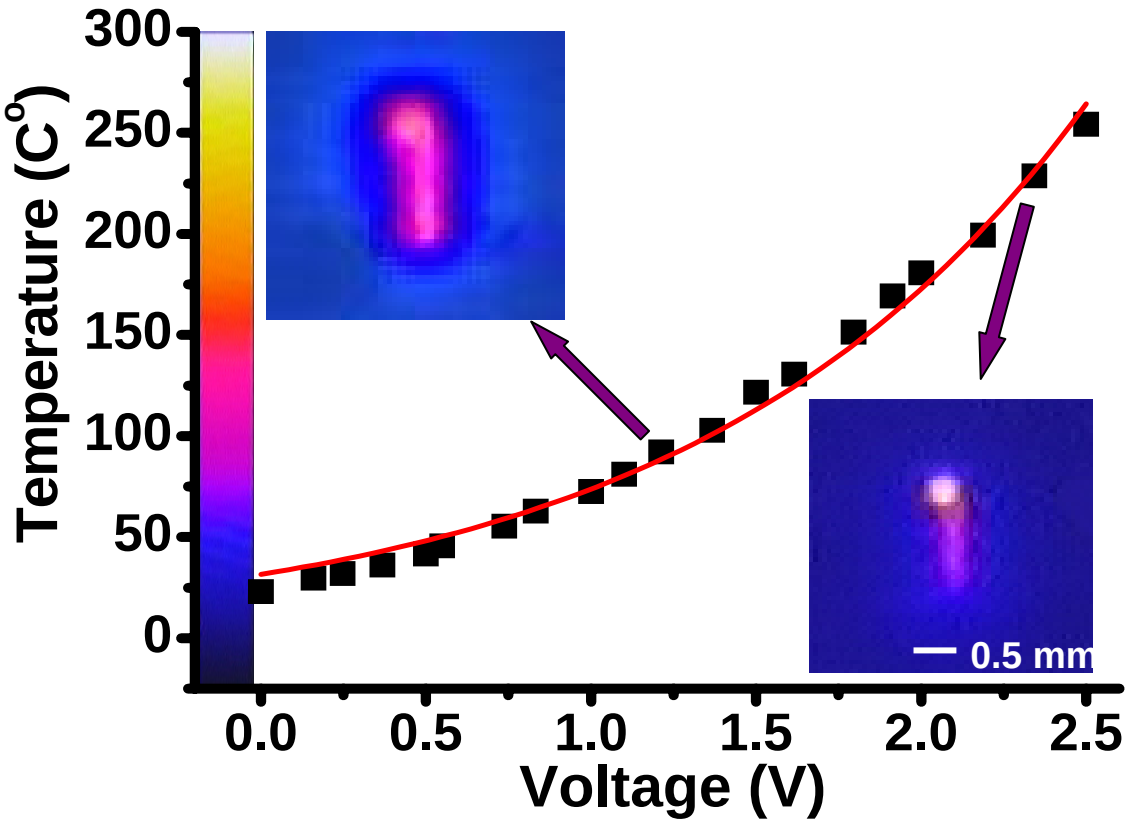

The two insets are IR pictures showing the thermal distributions at specific applied voltages. The bright spot on the right panel is a high temperature region with a temperature of ~250 ^{0}C

Response time

Time dependent temperature variations of the micro-heater

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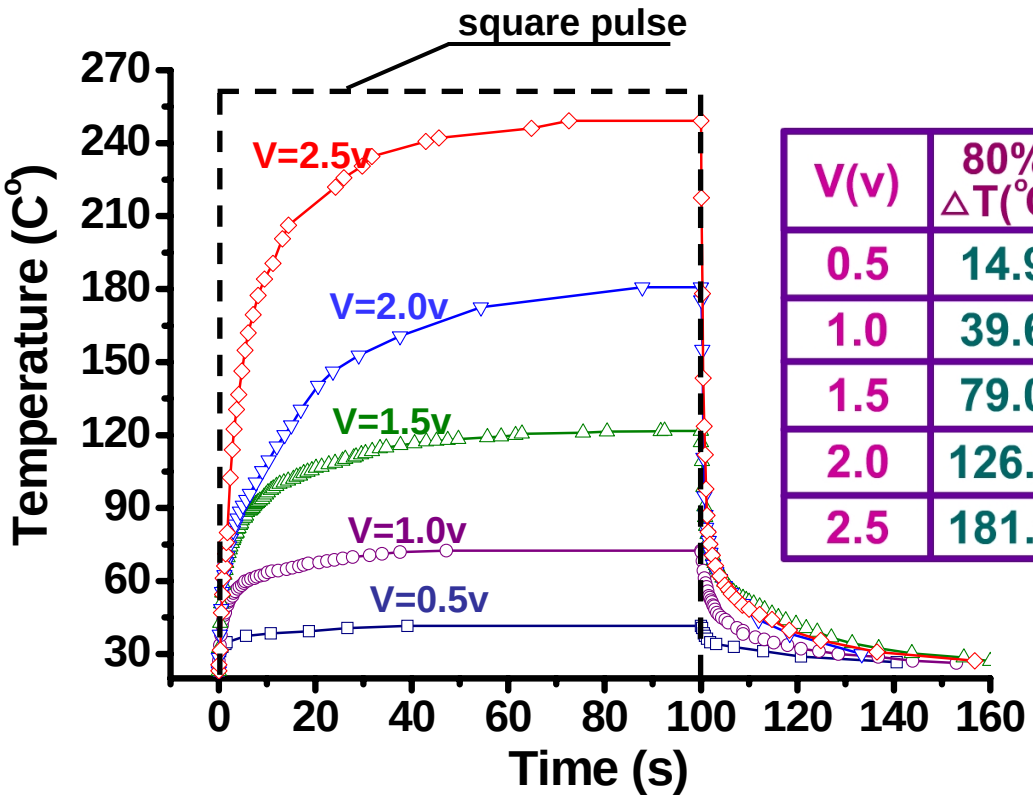

V(v)	80% △T(°C)	rise time(s)	decay time(s)
0.5	14.9	4.1	35.2
1.0	39.6	9.6	21.4
1.5	79.0	15.8	19.1
2.0	126.2	27.3	6.9
2.5	181.0	13.9	2.7

The right inset tabulates the temperature rise and decay times, defined at points where the temperature is 80% of the stabilized value.

Integration of multiple micro-heaters to form a thermal display

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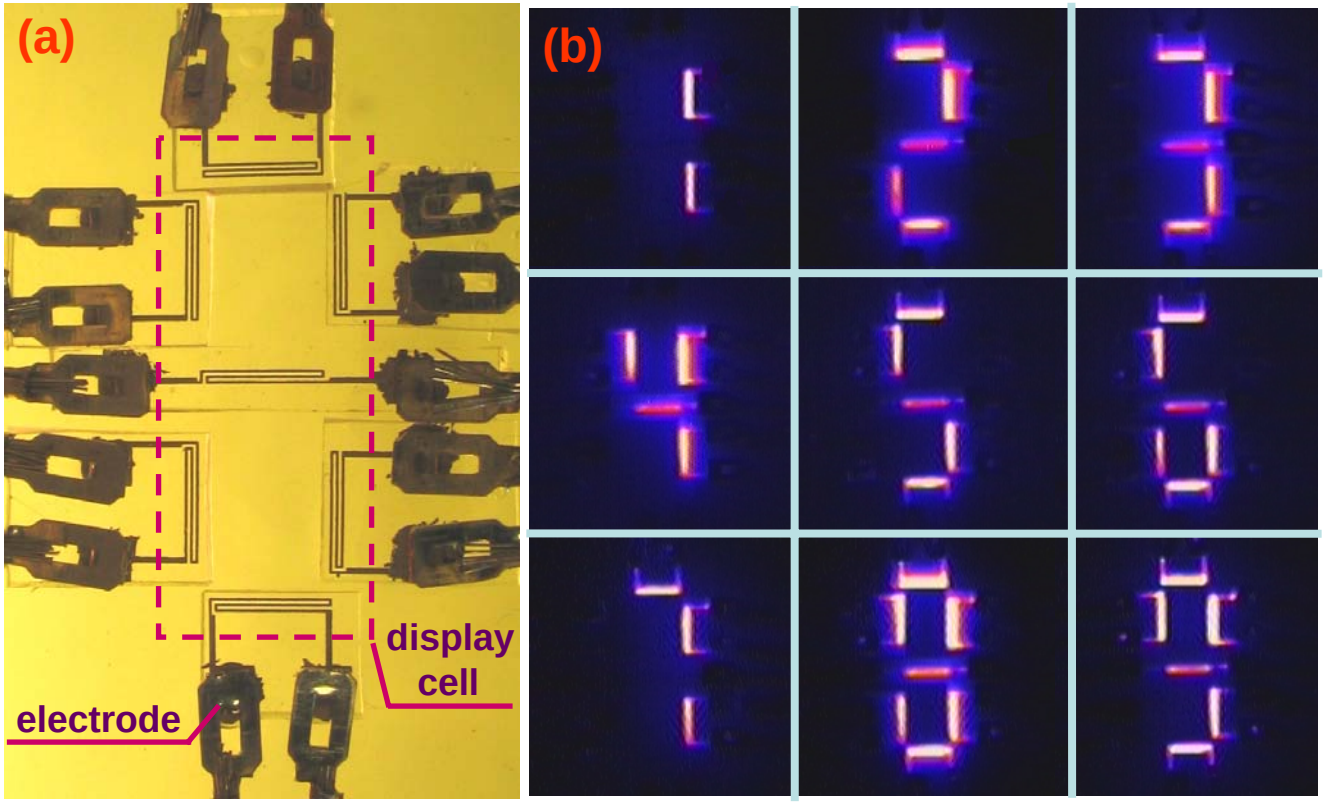

(b) shows the infrared images of the digits are displayed, demonstrating the ease and flexibility of operations.

Fabrication of thermochromic composite

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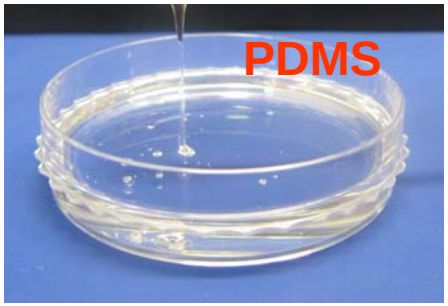
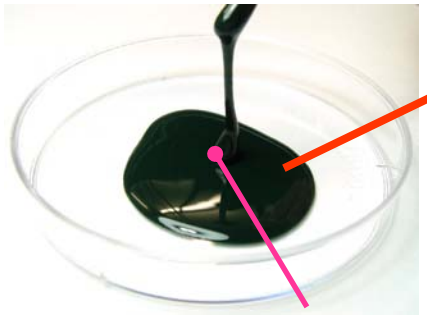
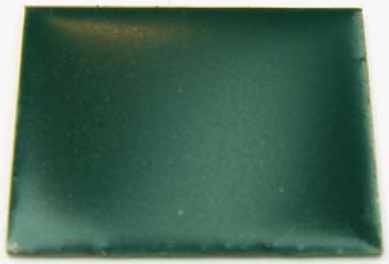
thermochromic nanopowder

+





liquid-like composite



cured thermochromic thin film

reeled film

Fabrication processing for paperlike thermochromic display

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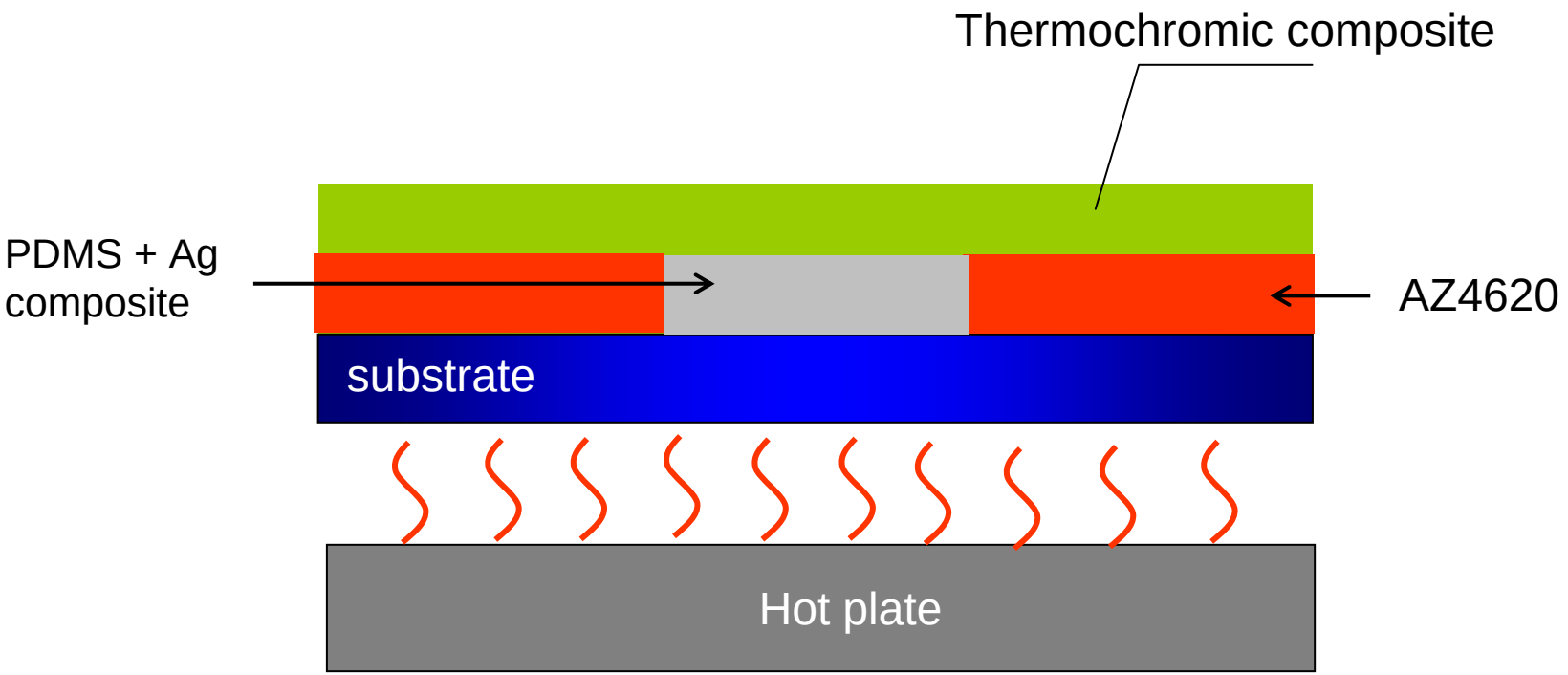

Structure of thermochromic thin film display

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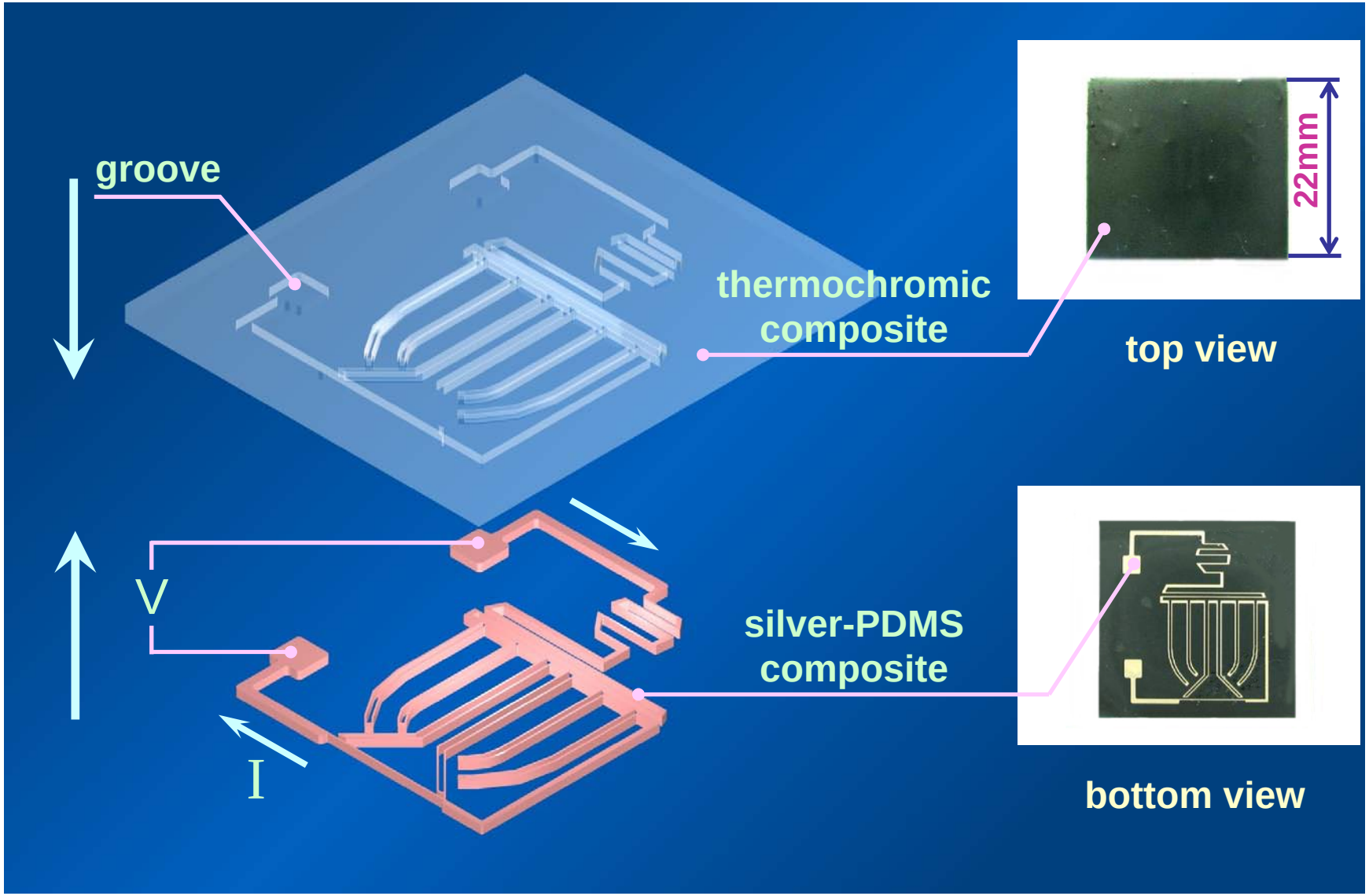

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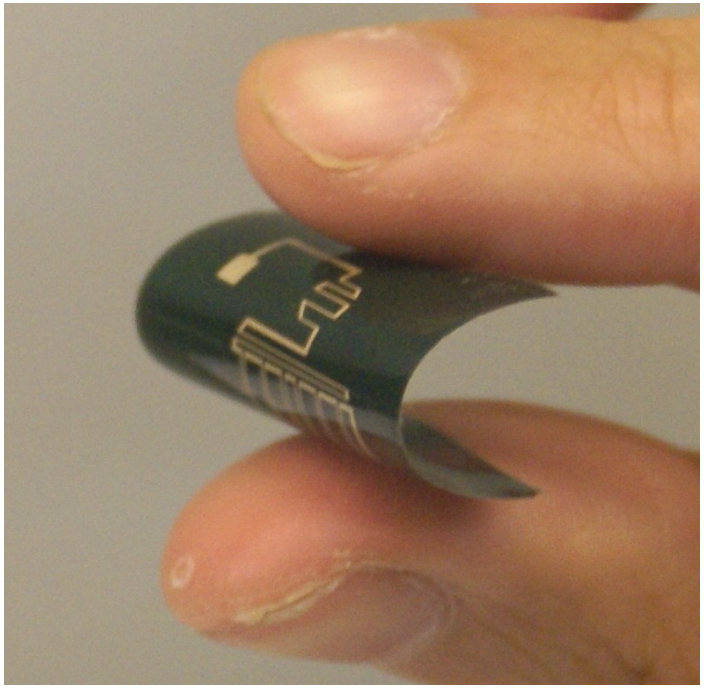

Display panel with flexible character

Image appears when power turns on

The display is wrapped on a column

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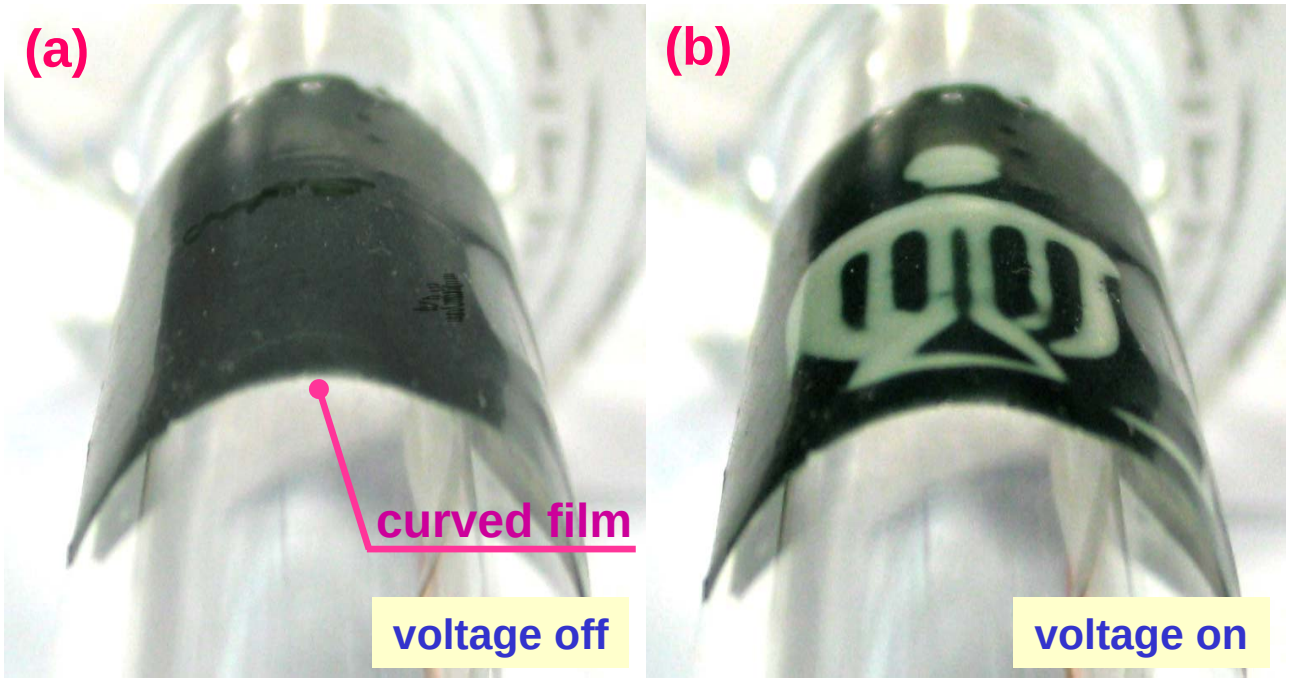

(a) shows the display film when no input signal is applied,

(b) shows the logo image to be correctly displayed when a voltage heating pulse train is applied

Display degree plotted as a function of applied voltage

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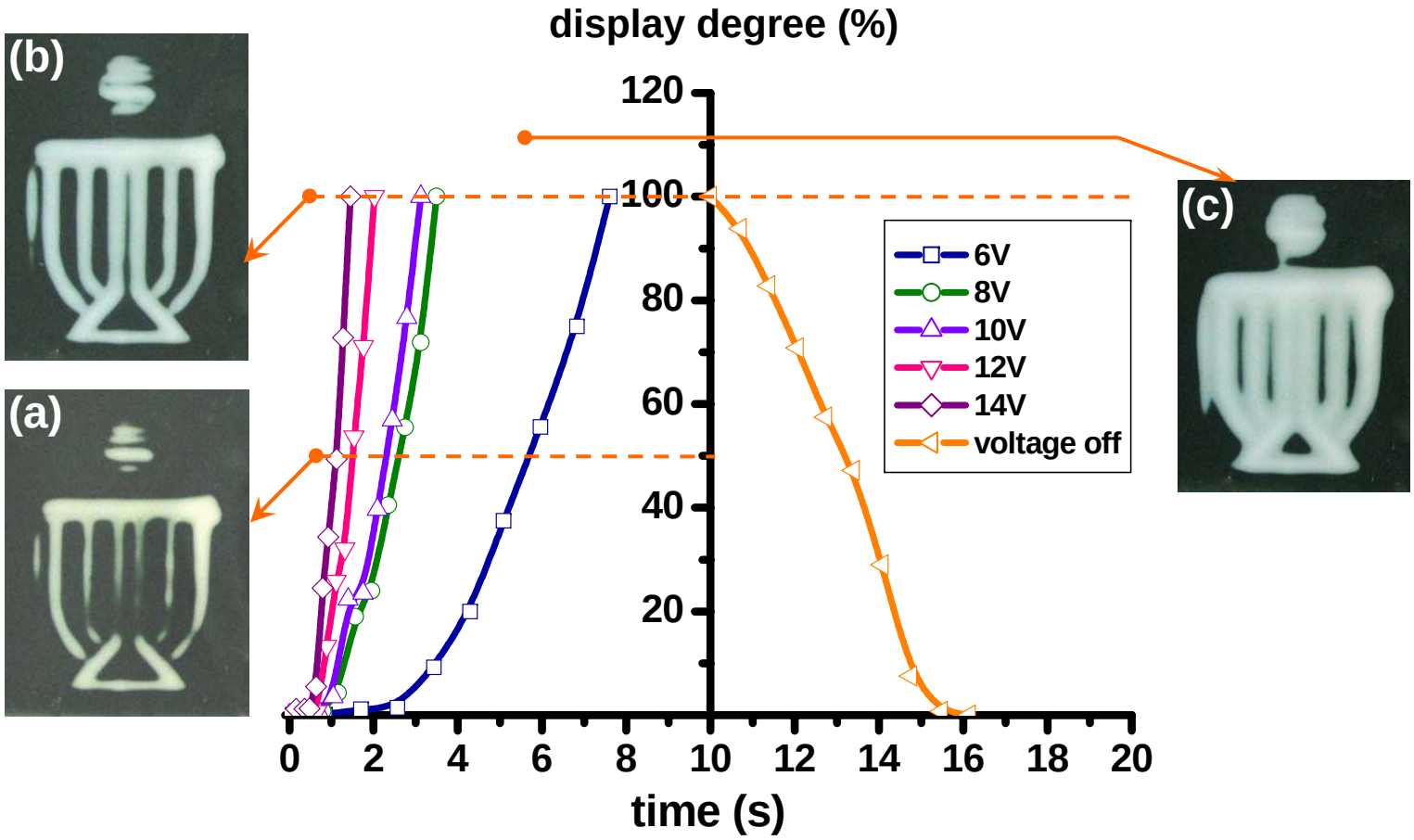

The five curves on the left correspond to a step function voltage of various height, while the one on the right corresponds to what happens after the voltage is turned off. The insets show the logo images at various display degrees. The image in inset C is blurred due to overheating

Power consumption of the display under different *t/T* ratios of the heating pulse train.

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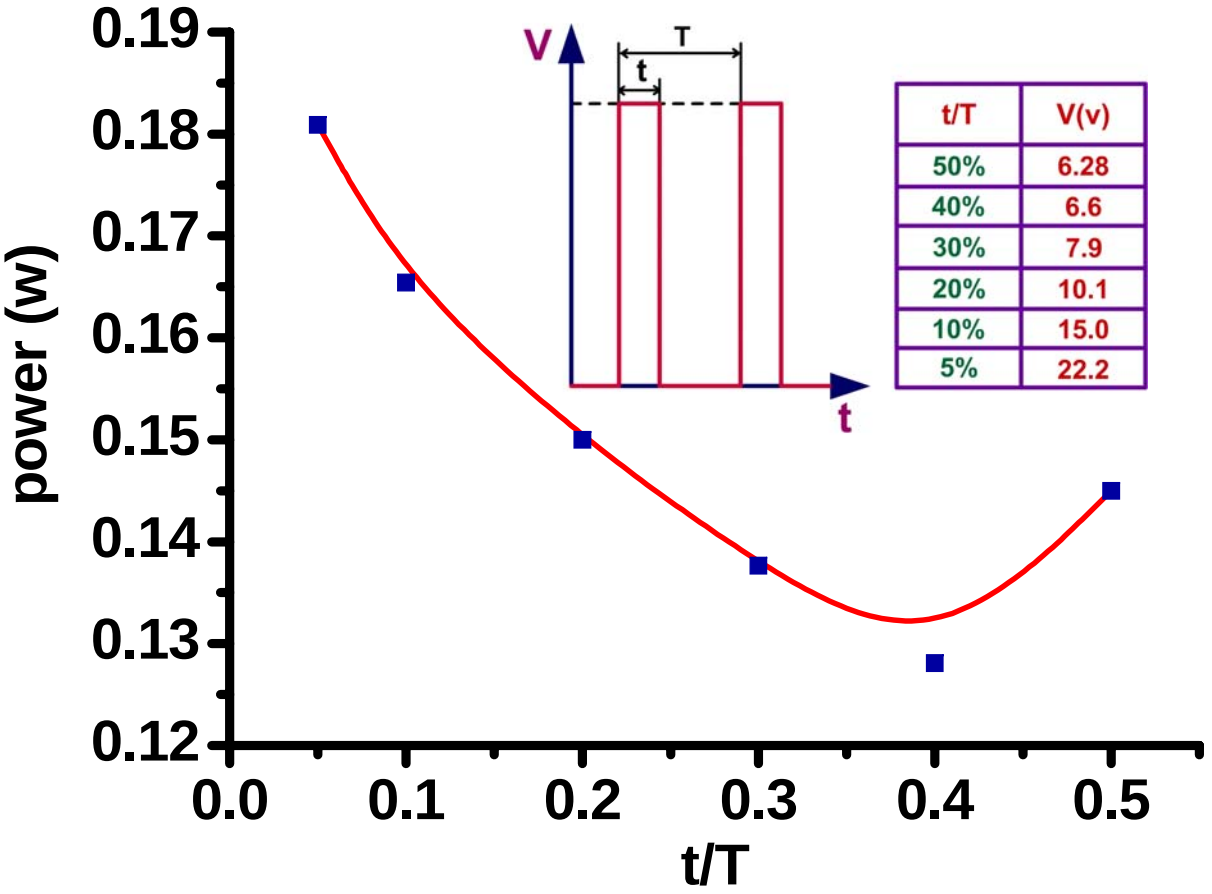

The duty cycle is fixed at 50Hz. The table gives the best voltage values (for achieving an accurate image) associated with the various values of *t/T* ratio.

Thanks

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