UNIVERSITY OF CALIFORNIA
College of Engineering
Department of Electrical Engineering and Computer Sciences

EE290D — Handout #6
Spring 1999 — T.-J. King

HOMEWORK ASSIGNMENT #1
Due Tuesday, February 2 (in class)

Problem 1: Substrate scaling
The glass substrate ("mother glass") area has been aggressively scaled up with each LCD production generation in order to rapidly reduce the manufacturing cost per panel. Standard substrate sizes for each generation are as follows:

Generation	Substrate Size (mm x mm)
I	300 x 400
II	360 x 465
III	550 x 650
III.5	650 x 830

These sizes were selected to accommodate 2, 4, 6, and 9 computer displays (~10-inch diagonal) per substrate. For the portable PC market, demand is now greatest for 12.1-inch diagonal displays. Assume that each display panel requires a 1 cm border, to allow space for cutting and beveling, and for tape-automated bonding (TAB) of display-driver chips.

a) How many 12.1-inch diagonal computer display panels can be fabricated on a single substrate, for a
- **i)** Generation II manufacturing facility ("fab")?
- **ii)** Generation III fab?
- **iii)** Generation III.5 fab?

Many LCD manufacturers are now mass-producing even larger panels (>13-inch diagonal -- too large for notebook PC applications), targeting the desktop-monitor market.

b) Consider the cost impact of increasing the display size beyond 13 inches in diagonal: at what size (rounding down to the nearest diagonal inch) would you expect to see an abrupt increase in manufacturing cost (per display), for a Generation III.5 facility?

Note: You can assume that the displays have square pixels; i.e. their aspect ratio = 640:480 = 800:600 = 4:3

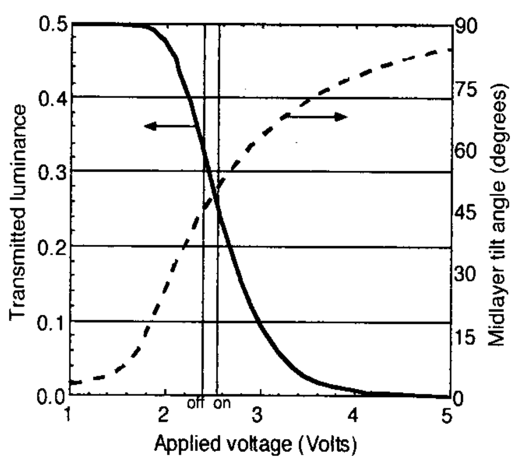
Problem 2: Pixel size and aperture ratio
a) Calculate the pixel size for a
- **i)** 10"D VGA display (e.g. an old notebook-PC display)
- **ii)** 12.1"D SVGA (e.g. a typical notebook-PC display today)
- **iii)** 15"D SXGA (e.g. a desktop-monitor)
- **iv)** 42"D VGA display (e.g. a PDP)

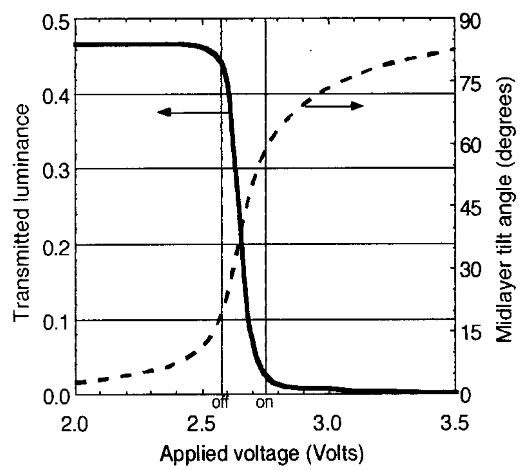
You may assume that the pixels are square.

b) Indium tin oxide (ITO) is employed as the transparent electrode material in LCDs and is typically patterned using conventional lithographic and wet-etch processes. A separate, patterned opaque thin-film, called the “black matrix”, is fabricated on the glass substrate(s) in a layer located either beneath or above the patterned ITO layer. The purpose of the black matrix is to block light in the regions of the LCD which are not well-controlled by the ITO electrodes. The resolution capability of state-of-the-art large-area lithography tools is 2 μm, with an overlay accuracy of 1 μm. Estimate the maximum pixel aperture ratio (active area / pixel area) for a 10”D VGA STN-LCD. (Because the electrodes are typically very thin (<0.15 μm), you may ignore the effect of undercutting during the ITO wet-etch process.)

<u>Problem 3</u>: Contrast ratio

The electro-optic characteristics for a TN-LCD (left) and a STN-LCD (right) are given below. (The vertical lines indicate the OFF and ON rms operating voltages for 240:1 multiplexing.





a) What is the maximum PCR for a dual-scan VGA TN-LCD display?
b) What is the maximum PCR for a dual-scan VGA STN-LCD display?
c) What is the maximum PCR for a dual-scan SVGA STN-LCD display?

<u>Problem 4</u>: Grey scale

The electro-optic characteristic of a TN-LC is as shown in Problem 3.

a) What is the maximum allowable change in pixel voltage during a frame time for a 6-bit color (262,140 colors) AMLCD?
b) Assuming a pixel capacitance of 1 pF, determine the maximum allowable pixel-TFT leakage current.

<u>Problem 5</u>: Reflective LCD technology

a) What are the advantages of reflective LCDs in comparison with transmissive LCDs?
b) Would active-matrix addressing be desirable for PDLC displays? Why or why not?