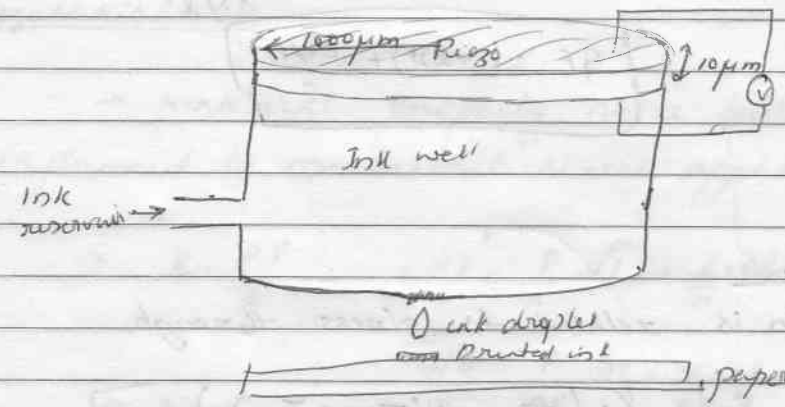
Lecture Note: Date: 8/1/2015 - jb

Piezoelectric effect: Problem

The figure below shows a schematic of a simplified model of an inkjet printer head that uses piezo electric actuation. It consists of a PZT disk of diameter 2000μm, and thickness 10μm. The disk is fixed to a frame at the top. The ink well is below the bottom surface. If this were to print with 600dpi (dots per inch) resolution with the printed film thickness of 2μm, determine the voltage to be applied to the PZT disk. The piezoelectric coefficient relating the strain in the thickness direction of the disk and the voltage applied is 480×10^{-12} m/V.

(Adapted from, Ananthaswamy, IISc)



Soln:

This converse piezoelectric effect.

Hence strain $\varepsilon \propto E$ (E - electric field

$\propto V/t$ (V: voltage

t: thickness

$\varepsilon = d\, V/t$

Oddy

Let us In order to calculate voltage, we should first calculate strain.

Now strain: $\frac{\delta}{L} = \frac{\text{change in length}}{\text{actual length}}$.

How to calculate change in length?

ie. We have to calculate the displacement of PZT from its initial length so that a single ink droplet is ejected from it. Hence δ = volume of the droplet / cross-section area of the ink well.

Now it is given that the print resolution is 600 dpi i.e. 600 drops/inch. → 600 circular dots per inch. Hence the diameter of a single dot is $\frac{1}{600}$ inch. = 0.0017 inch = 42.3 μm. The thickness of the printed film is 2 μm.

So volume = Area × thickness

$$= \frac{\pi \times (42.3 \times 10^{-6})^2}{4} \times 2 \times 10^{-6}$$

$$= 2.8106 \times 10^{-15} \text{ m}^3$$

δ = Cross-section area of the ink well: $\pi D^2/4$, Here D = 2000 μm $= 2 \times 10^{-3}$ m

$$= \frac{\pi \times (2 \times 10^{-3})^2}{4}$$

$$\delta = \frac{2.8106 \times 10^{-15}}{\pi \times (2 \times 10^{-3})^2/4} = 8.9464 \times 10^{-10} \text{ m}$$

Strain $\varepsilon = \delta/L = \frac{8.9464 \times 10^{-10}}{10 \times 10^{-6}} = 8.9464 \times 10^{-5}$

Oddy

$\epsilon = V/t \cdot d$

$V = \epsilon \cdot t / d$

$= \dfrac{8.9464 \times 10^{-5} \times 10 \times 10^{-6}\ m}{480 \times 10^{-12}\ m/V}$

$= 0.186 \times 10^{-11} \times 10^{12}\ V$

$\boxed{V = 1.86\ V}$

Oddy