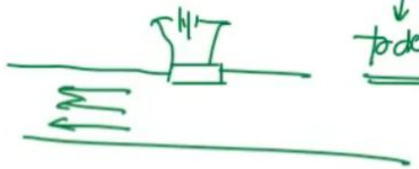
SMI-L-08

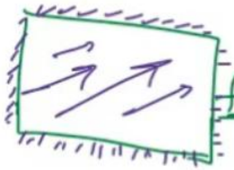
Thursday, February 10, 2022 1:25 PM

Piezo-resistors → sensor
→ actuator

deform



Piezo-resistivity → The change in the resistance, application of force → stress
↳ strain



film → bend
→ bulge
→ Change in resistance
↓
Vout

Piezo-resistivity → The change in the resistance, application of force → stress
↳ strain

film → bend / bulge → Change in resistance → Vout → interpretation to get the physical meaning

deformation → bend / bulge

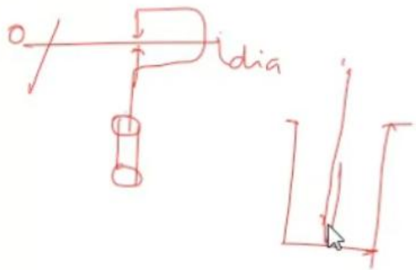
deformation → strain → stress

Piezo-resistivity → The change in the resistance, application of force → stress
↳ strain

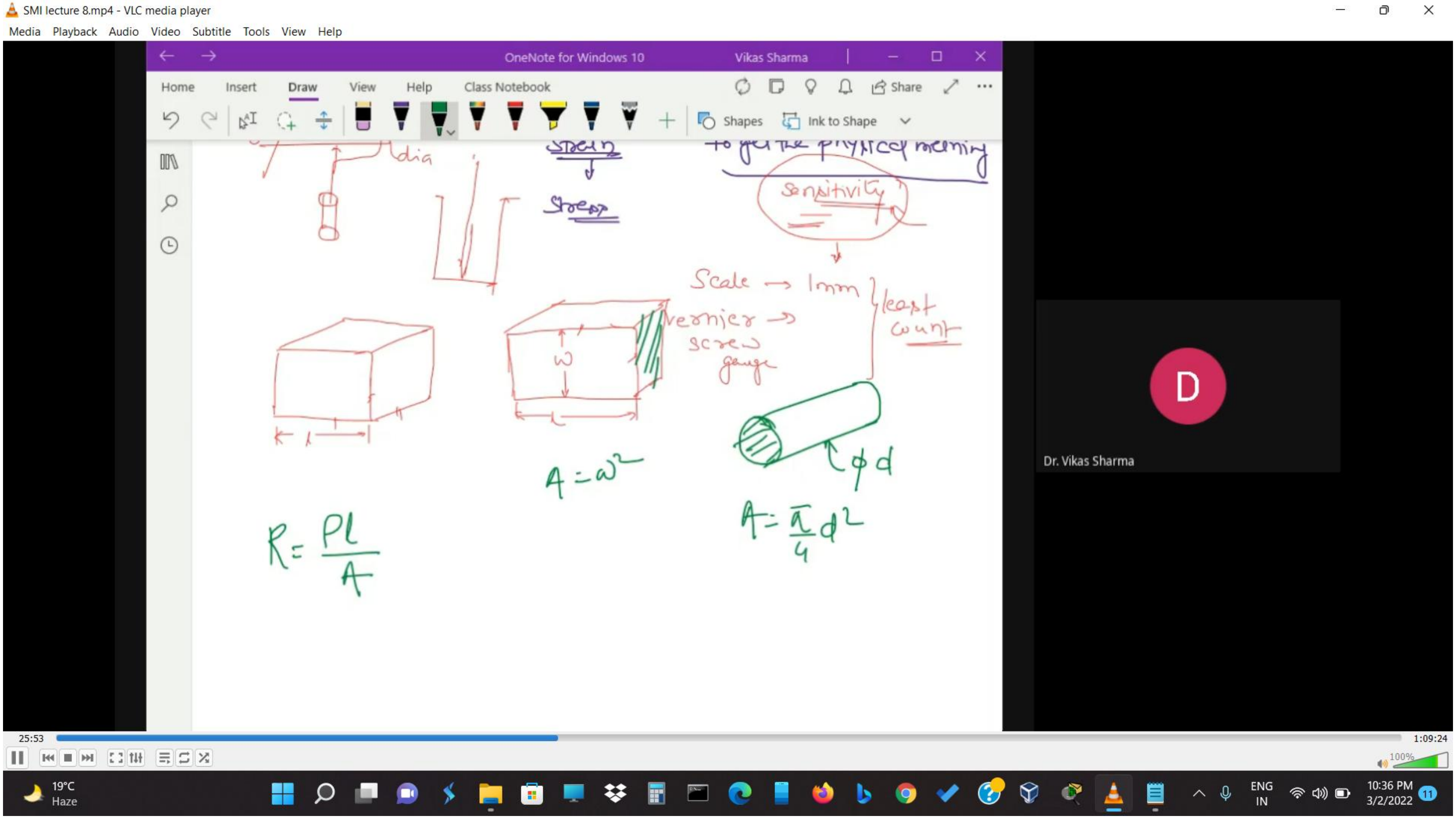
film → bend / bulge } → Change in resistance

deformation ↑ (bulge)
↓
strain
↓
stress

Change in resistance
↓
Vout
↓
interpretation
to get the physical meaning
↓
sensitivity
↓



Scale → 1mm
vernier → screw gauge
} least count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Share
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dia
Strain
Stress
to get the physical meaning
Sensitivity
Scale → 1mm
vernier →
screw gauge
least count
w
l
ϕd
A = w²
R = ρl/A
A = π/4 d²
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D
25:53
1:09:24
100%
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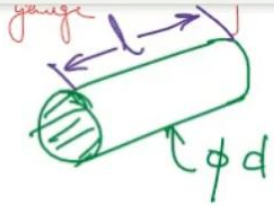

electrical resistivity

$A = w^2$

$A = \frac{\pi}{4} d^2$

$R = \frac{\rho l}{A}$ — length — Area (cross section)

$R = \frac{\rho l}{w^2}$; $R = \frac{\rho l}{\frac{\pi}{4} d^2}$

D

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27:31 1:09:24 100%

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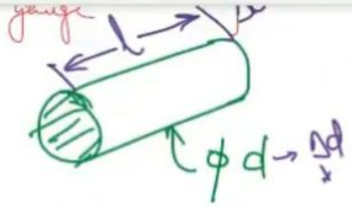

$\phi\, d \rightarrow \Delta d$

electrical resistivity

$A = w^2$

$A = \frac{\pi}{4} d^2$

$R = \frac{\rho l}{A}$ length, Area (cross section)

elastic strain $= \frac{\Delta l}{l}$

$R = \frac{\rho l}{w^2}$; $R = \frac{\rho l}{\frac{\pi}{4} d^2}$

Poisson's Ratio

$\Delta w = -\nu \epsilon w$

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31:18 1:09:24

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electrical resistivity

$A = w$

① $\boxed{R = \frac{\rho l}{A}}$ → length, → Area (cross section)

$A = \frac{\pi}{4} d^2$

elastic strain $= \frac{\Delta l}{l}$

$R = \frac{\rho l}{w^2}$; $R = \frac{\rho l}{\frac{\pi}{4} d^2}$

Poisson's Ratio

$$\Delta w = -\nu \epsilon w$$

Partial derivative of the eq ①

$$\Delta R = \frac{\rho}{A}\Delta l + \frac{l}{A}\Delta \rho + \rho l \left(-\frac{1}{A^2}\right)\Delta A$$

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What is the change in resistence undergoing deformation

$$\Delta R = \frac{\rho}{A}\Delta l + \frac{l}{A}\Delta \rho + \rho l\left(-\frac{1}{A^2}\right)\Delta A$$

$$\frac{\Delta R}{R} = \frac{\Delta l}{l} + \frac{\Delta \rho}{\rho} - \frac{\Delta A}{A}$$

for a cylindrical body

$$\frac{\Delta R}{R} = \frac{\Delta l}{l} + \frac{\Delta \rho}{\rho} - 2\frac{\Delta D}{D}$$

for cuboid:

$$\frac{\Delta R}{R} = \frac{\Delta l}{l} + \frac{\Delta \rho}{\rho} - 2\frac{\Delta \omega}{\omega}$$

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37:47 / 1:09:24

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for a cylindrical body

$$\frac{\Delta R}{R} = \frac{\Delta l}{l} + \frac{\Delta \rho}{\rho} - \frac{2\Delta D}{D}$$

for cuboid:

$$\frac{\Delta R}{R} = \frac{\Delta l}{l} + \frac{\Delta \rho}{\rho} - 2\frac{\Delta \omega}{\omega}$$

final exp

$$\frac{\Delta R}{R} = \epsilon + \frac{\Delta \rho}{\rho} + 2\nu\epsilon$$

$$\frac{\Delta R}{R} = (1+2\nu)\epsilon + \Delta\rho/\rho$$

D

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38:51 1:09:24

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final exp

$$\frac{\Delta R}{R} = \epsilon + \frac{\Delta \rho}{\rho} + 2\nu\epsilon$$

$$\frac{\Delta R}{R} = (1+2\nu)\epsilon + \Delta\rho/\rho$$

Gauge factor

$$\frac{\Delta R/R}{\epsilon} = \frac{\Delta \rho}{\rho\epsilon} + (1+2\nu)$$

Silicon & Germanium

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41:02 1:09:24

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final exp

$$\frac{\Delta R}{R} = \epsilon + \frac{\Delta \rho}{\rho} + 2\nu\epsilon$$

$$\frac{\Delta R}{R} = (1+2\nu)\epsilon + \Delta\rho/\rho$$

Gauge factor

$$\frac{\Delta R/R}{\epsilon} = \frac{\Delta \rho}{\rho\epsilon} + (1+2\nu)$$

deformation

Silicon & Germenium

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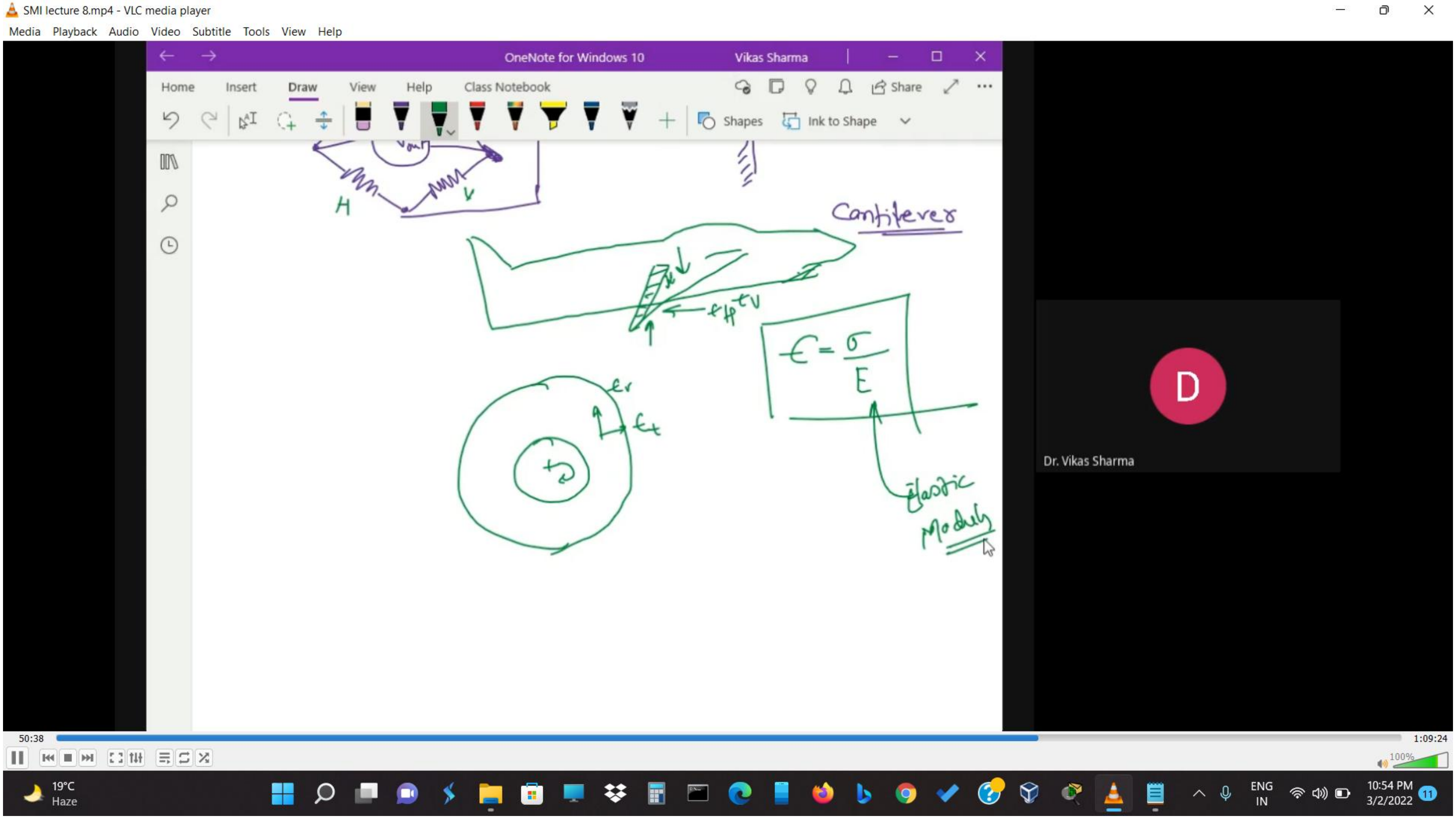
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V
Cantilever
$\epsilon = \frac{\sigma}{E}$
ϵ_r
ϵ_t
Elastic Modulus
D
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50:38
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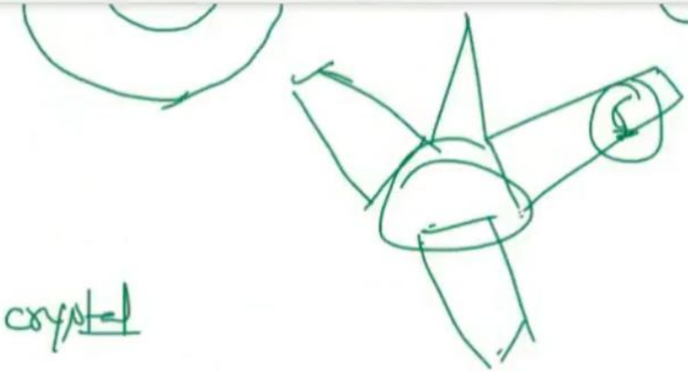

Modulus

Silicon & Ge

→ Single crystal

deforming

↓

Strain → energy band structure

→ Change in mobility of carrier

holes electrons

↓

Change in resistance

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→ single crystal

deforming ↓

strain → energy band structure

↳ change in mobility of carrier

holes electrons

↓

Change in resistance

(G)

↓

$$\text{Gauge factor} = \frac{\Delta R/R}{\epsilon} = \frac{\Delta R/R}{\sigma/E}$$

$$\frac{\Delta R}{R} = \left(\frac{G}{E}\right)\sigma$$

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→ Change in mobility of carrier

holes electrons

Change in resistance

(G)

$$\text{Gauge factor} = \frac{\Delta R/R}{\epsilon} = \frac{\Delta R/R}{\sigma/E}$$

$$\frac{\Delta R}{R} = \left(\frac{G}{E}\right)\sigma$$

→ piezo-resistive coefficient (π)

$$\Delta R/R = \pi\sigma$$

M

D

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change in resistance

$$\text{Gauge factor} = \frac{\Delta R/R}{\epsilon} = \frac{\Delta R/R}{\sigma/E}$$

$$\frac{\Delta R}{R} = \left(\frac{G}{E}\right)\sigma$$

$\left(\frac{G}{E}\right) \to$ piezo-resistive coefficient (π)

$$\Delta R/R = \pi\sigma$$

Metal foil - 1 to 5
(foil 100 mic)

poly crystal material = 30 approx.

diffused semiconductor = 80 to 200

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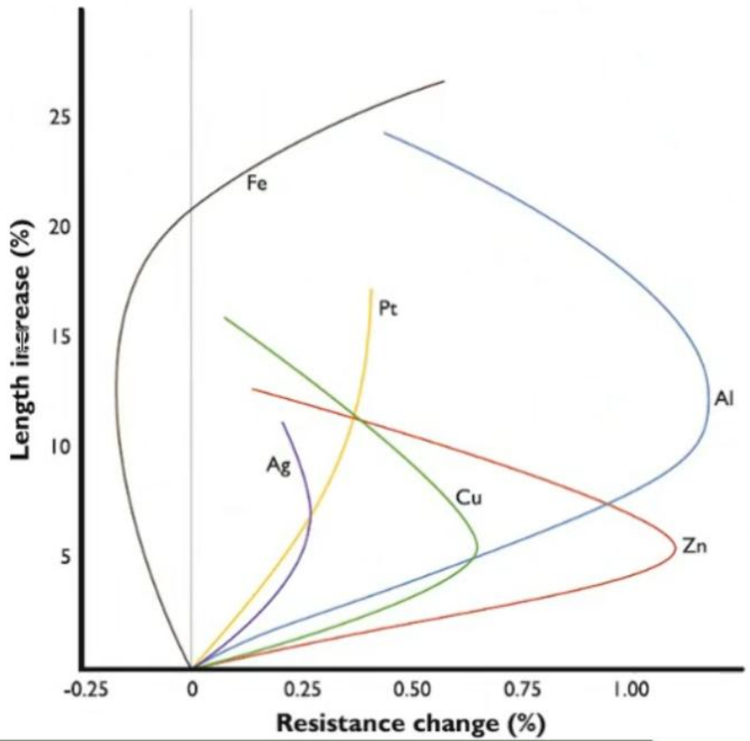
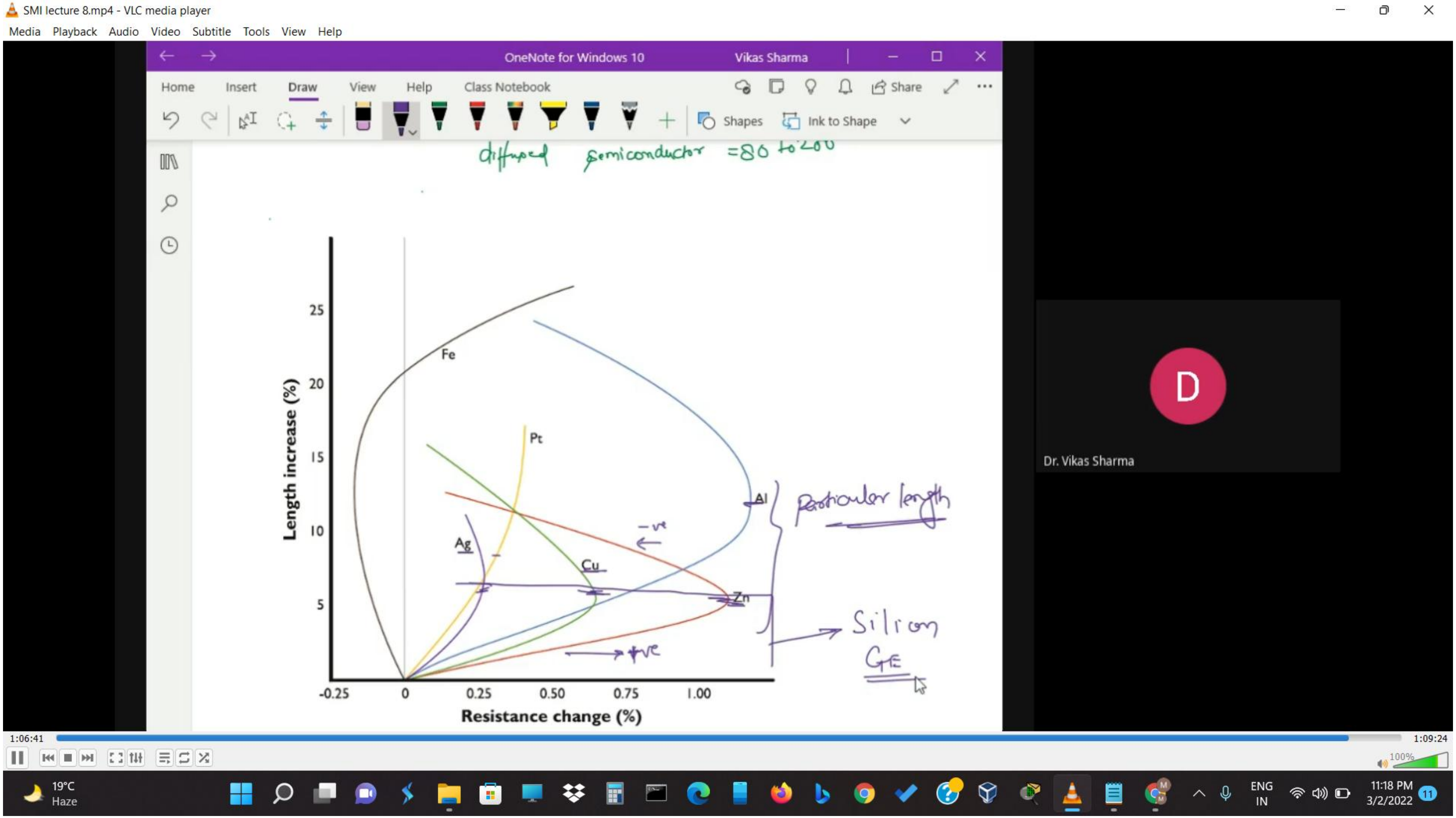
diffused semiconductor =80 to 200

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Shapes Ink to Shape
diffused semiconductor =80 to 200
Length increase (%)
25
20
15
10
5
Fe
Pt
Al
Ag
Cu
Zn
-ve
+ve
Particular length
Silicon
GE
-0.25
0
0.25
0.50
0.75
1.00
Resistance change (%)
D
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1:06:41
1:09:24
100%
19°C
Haze
ENG
IN
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