

OneNote for Windows 10 Vikas Sharma

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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



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

The diagram illustrates the piezo-resistive effect. A rectangular film is shown on the left with diagonal lines representing its internal structure. An arrow labeled 'film' points to a central point where two paths diverge. The upper path is labeled 'bend' and 'bulge', leading to 'Change in resistance'. The lower path is labeled 'deformation', leading to 'strain', which then leads to 'stress'. From 'Change in resistance', an arrow points down to 'Vout', which then leads to 'interpolation to get the physical meaning'.



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

film → bend / bulge → Change in resistance

deformation → strain → stress

V_{out} → interpolation to get the physical meaning → sensitivity

Scale → 1mm } least count
 vernier →
 screw gauge



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Shapes Ink to Shape

dia

Scale → 1mm

vernier → screw gauge

least count

$R = \frac{PL}{A}$

$A = \omega^2$

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

ϕd

to get the physical meaning

Sensitivity

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electrical resistivity $A = \omega^2$

$R = \frac{PL}{A}$ length Area (cross section)

$R = \frac{Pl}{\omega^2}$: $R = \frac{Pl}{\frac{\pi}{4}d^2}$

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Diagram 1: A rectangular wire of length l and cross-sectional area A is shown. The area is labeled as $A = \omega^2$.

Diagram 2: A cylindrical wire of length l and diameter d is shown. The area is labeled as $A = \frac{\pi d^2}{4}$.

Equation 1: $R = \frac{\rho l}{A}$

Annotations for Equation 1:

- ρ : electrical resistivity
- l : length
- A : Area (cross section)

Equation 2: $R = \frac{\rho l}{\omega^2}$

Equation 3: $R = \frac{\rho l}{\frac{\pi d^2}{4}}$

Equation 4: $R = \frac{4 \rho l}{\pi d^2}$

Equation 5: $\Delta \omega = -v \epsilon \omega$

Equation 6: $\text{elastic strain} = \frac{\Delta l}{l}$



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① $R = \frac{\rho L}{A}$

electronic resistivity ρ

length L

Area (cross section) A

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

elastic plowing $= \frac{\Delta L}{L}$

$R = \frac{\rho L}{\omega^2}$ $\therefore R = \frac{\rho L}{\frac{\pi d^2}{4}}$

Poisson's Ratio

$\Delta \omega = -\nu \epsilon \omega$

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 resistance undergoing deformation → $\Delta R = \frac{P}{A} \Delta L + \frac{L}{A} \Delta P + P l \left(-\frac{1}{A^2} \right) \Delta A$

$$\frac{\Delta R}{R} = \frac{\Delta L}{L} + \frac{\Delta P}{P} - \frac{\Delta A}{A}$$

for cylindrical body

$$\frac{\Delta R}{R} = \frac{\Delta L}{L} + \frac{\Delta P}{P} - \frac{2\Delta D}{D}$$

for cuboid:

$$\frac{\Delta R}{R} = \frac{\Delta L}{L} + \frac{\Delta P}{P} - 2 \frac{\Delta a}{a}$$


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for cylindrical body

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

for unboid:

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

final exp

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

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



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Undo Redo Select Eraser Pencil Highlighter Ink Eraser Eraser

Shapes Ink to Shape

$R = L \cdot \rho \cdot \omega$

final exp

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

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

Gauge factor

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

Silicon & Germanium

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D

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Shapes Ink to Shape

$R = L \cdot \rho \cdot \omega$

final exp

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

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

Gauge factor

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

deformation

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The diagrams include:

- A stress-strain curve with labels H and V .
- A diagram of a beam under stress with labels ϵ_p and ϵ_t .
- A circular diagram with labels ϵ_r and ϵ_t .
- A box containing the equation $\epsilon = \frac{\sigma}{E}$.
- The text "Coniferex" and "Elastic Modulus" with an arrow pointing to the equation box.

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Shapes Ink to Shape

Silicon & Ge

deforming → single crystal

strain → energy band structure

→ change in mobility of carrier

↓

holes electrons

Change in resistance

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deforming single crystal

strain → energy band structure

↓ change in mobility of carrier

↓ holes electrons

Change in resistance

(G)

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
↓
Change in resistance
↓
holes electrons

(G)
↓
Gauge factor = $\frac{\Delta R/R}{\epsilon} = \frac{\Delta R/R}{\sigma/E}$

$\frac{\Delta R}{R} = \left(\frac{G}{E}\right) \sigma$
↓
piezo. relative coefficient (π)

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

M



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Change in resistance

$$\text{Gauge factor} = \frac{\Delta R/R}{\epsilon} = \frac{\Delta R/R}{\sigma/E}$$
$$\frac{\Delta R}{R} = \left(\frac{G}{E} \right) \sigma$$

↳ piezo. relative coefficient (π)

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

Metal foil - 1 to 5
(for 100 mic)

poly crystal material = 30 approx

diffused semiconductor = 80 to 200



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