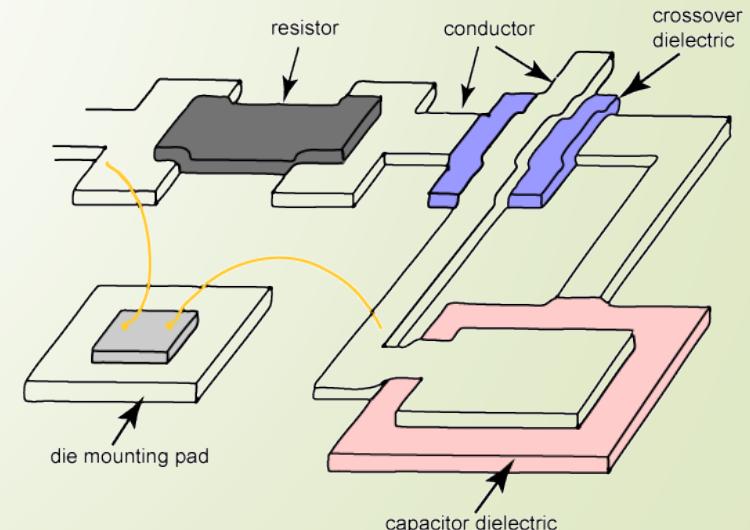


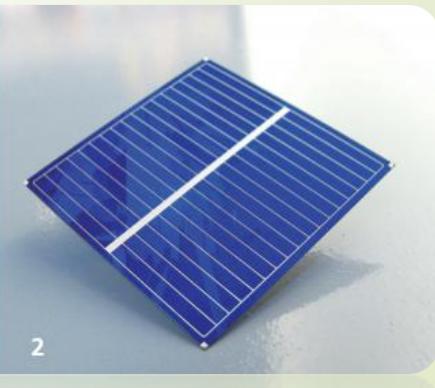
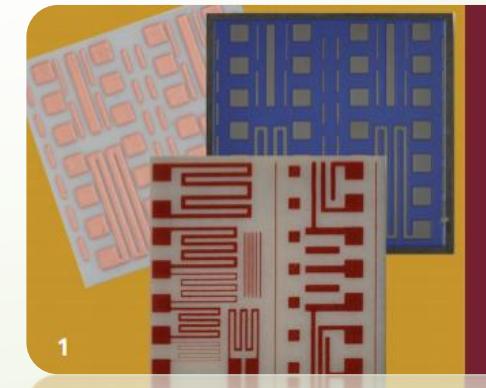
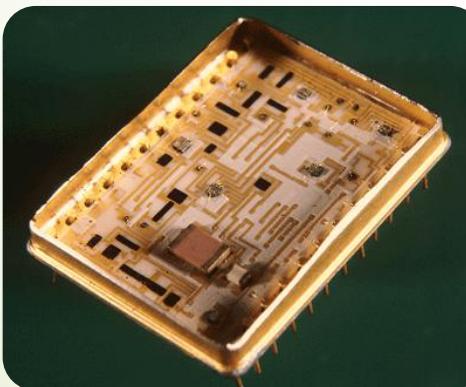
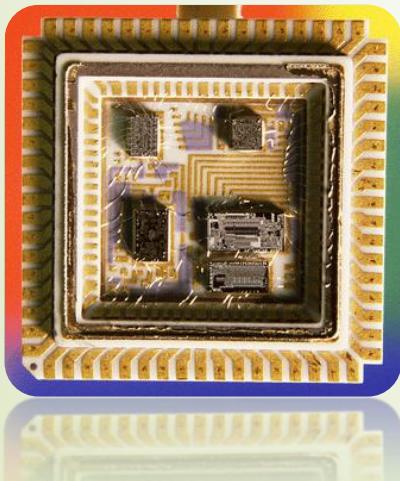
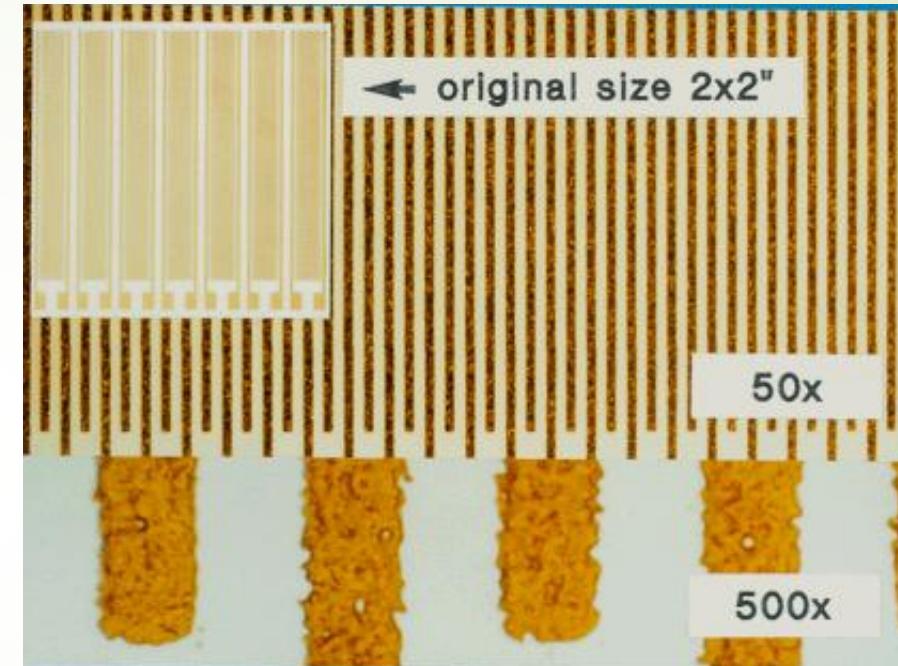
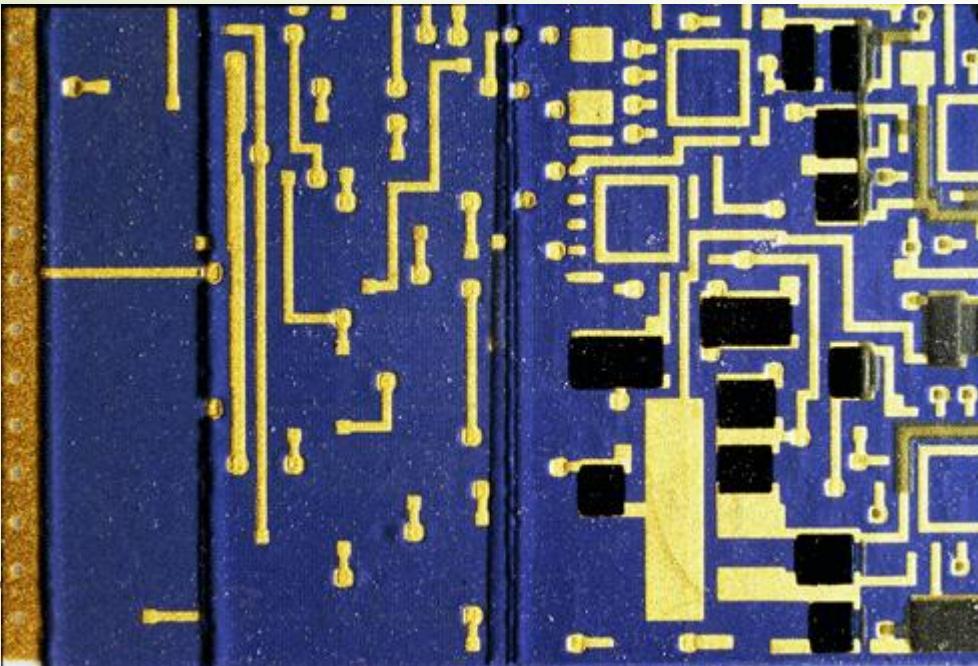
TEKNOLOGI FILM TEBAL MIKROELEKTRONIKA

Eka Maulana, ST, MT, MEng.

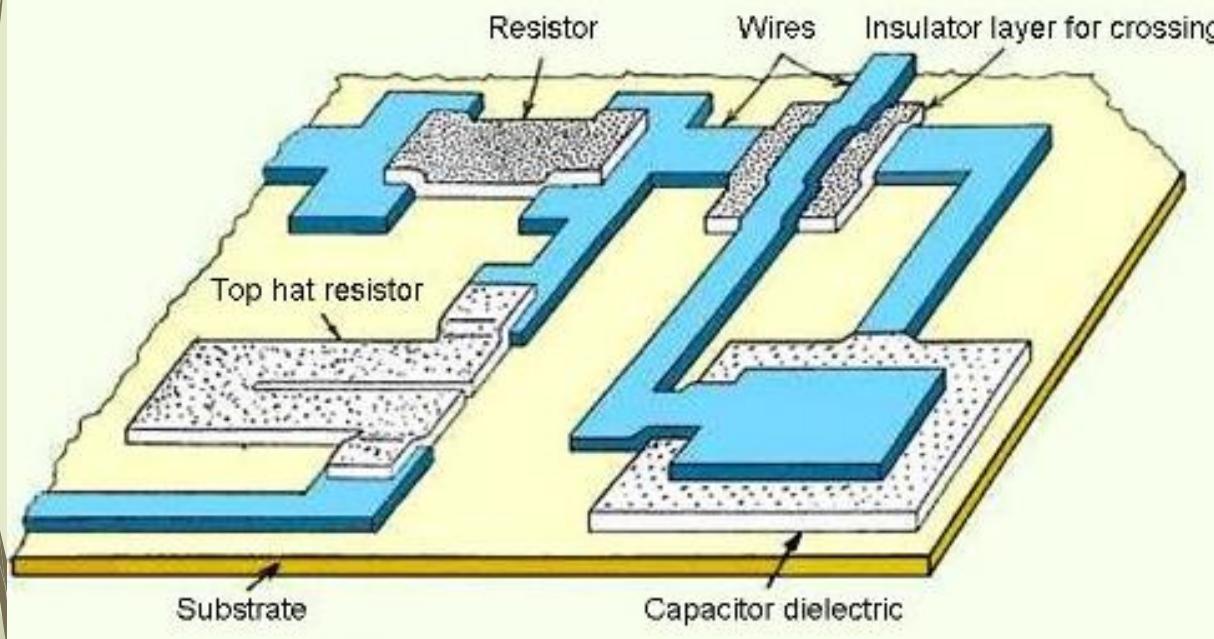
Teknik Elektro
Universitas Brawijaya



Pengantar: Perkembangan Teknologi



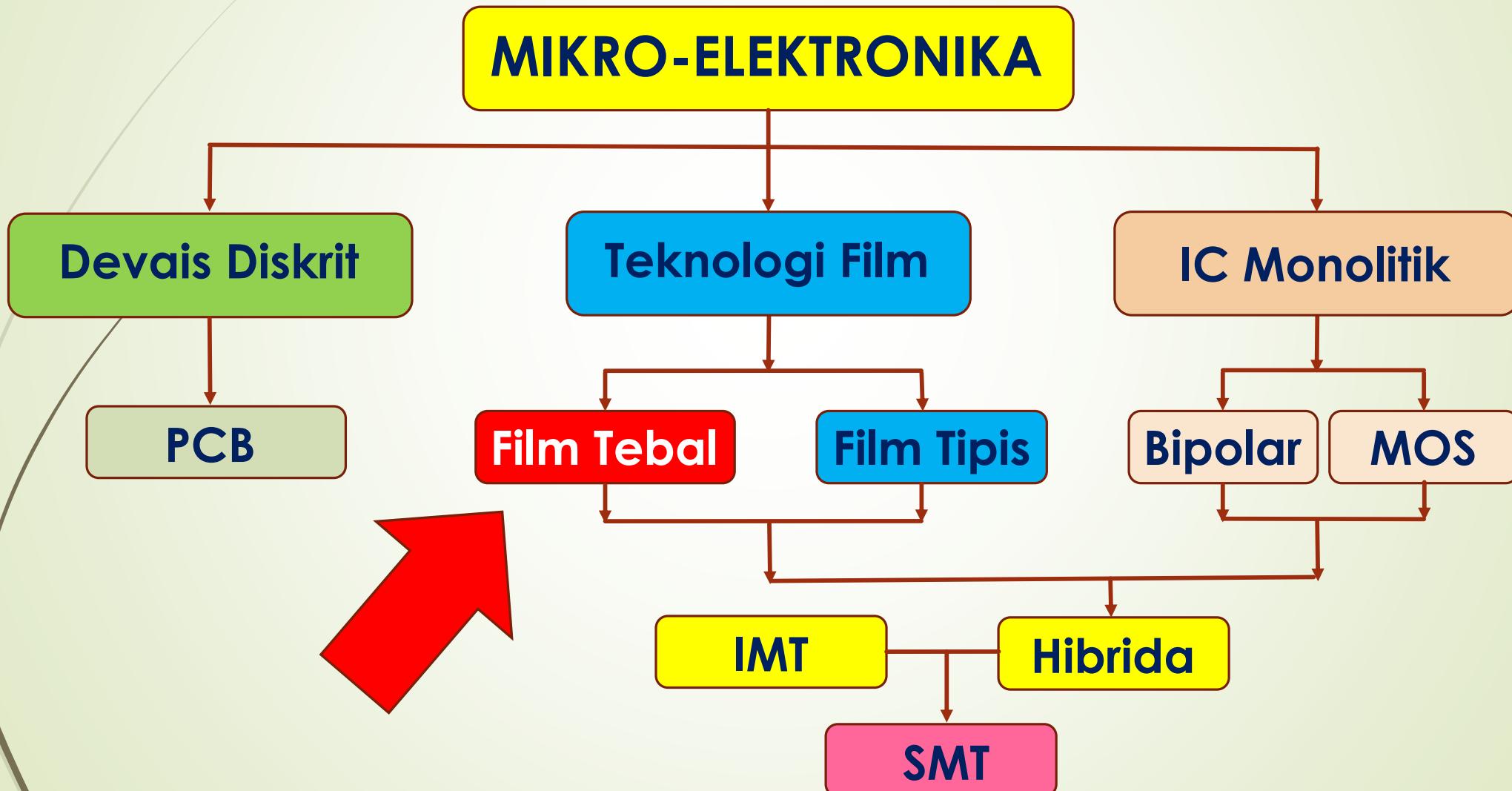
Gambaran Teknologi Film Tebal



Thick film

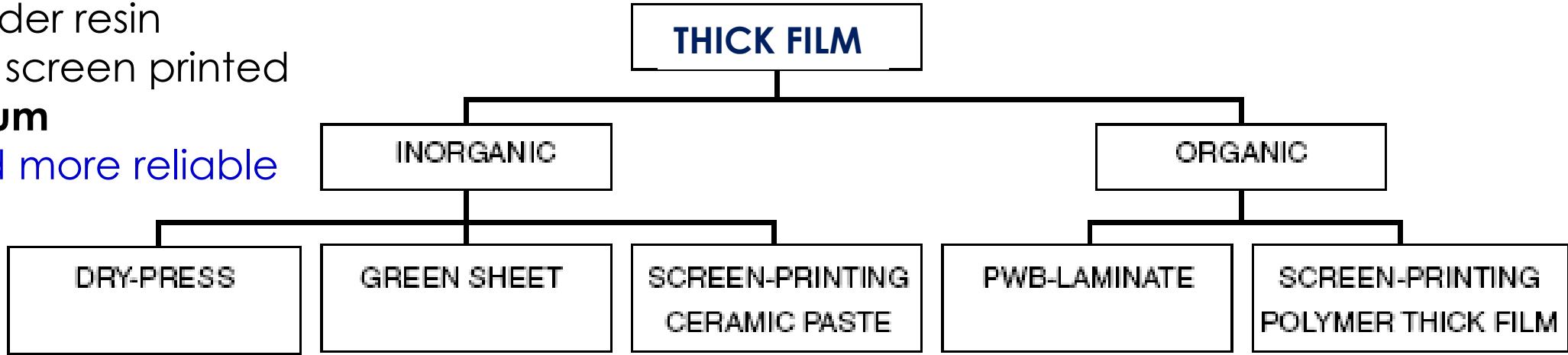
- Teknologi 'printing & firing' menggunakan pasta konduktif, resistive, kapasitif dan insulasi yang didepositikan pada pola (pattern) melalui screen printing dan diproses pada suhu tinggi diatas substrat kramik.
- Ketebalan 5–20 μm
- Resistivitas is $10\Omega/\text{sq}$ - $10M\Omega/\text{sq}$.

KLASIFIKASI TEKNOLOGI MIKROELEKTRONIKA

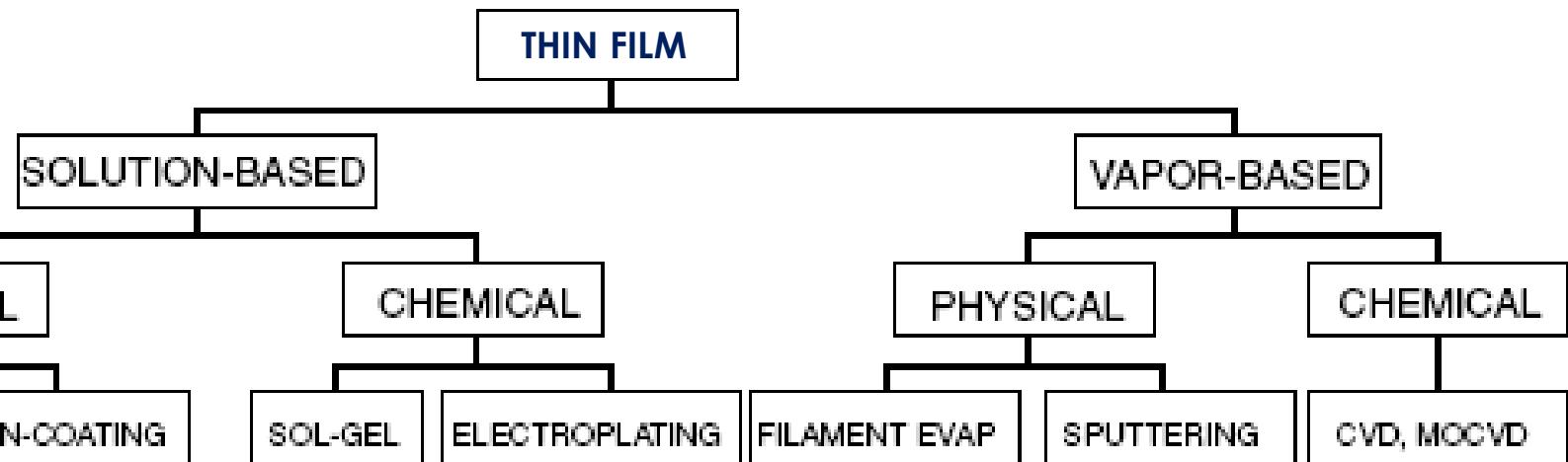


Klasifikasi Proses Film Tebal dan Film Tipis

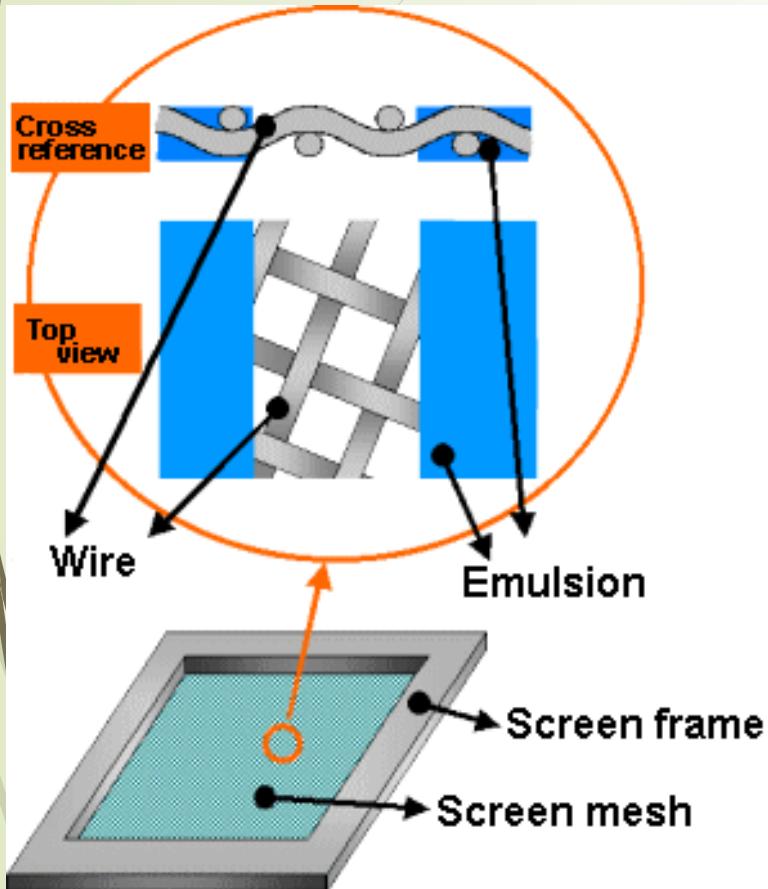
Metal powder resin
composite screen printed
Thickness: **um**
considered more reliable



Metal thin film deposited in
molecular/atomic process
Thickness: **nm**
Better performance



Material



1. Screen

Screen merupakan tenunan berlubang-lubang yang terbuat dari serat yang fungsinya adalah untuk menentukan pola yang akan dicetak dan menentukan ketebalan pasta yang akan ditempelkan pada substrat.

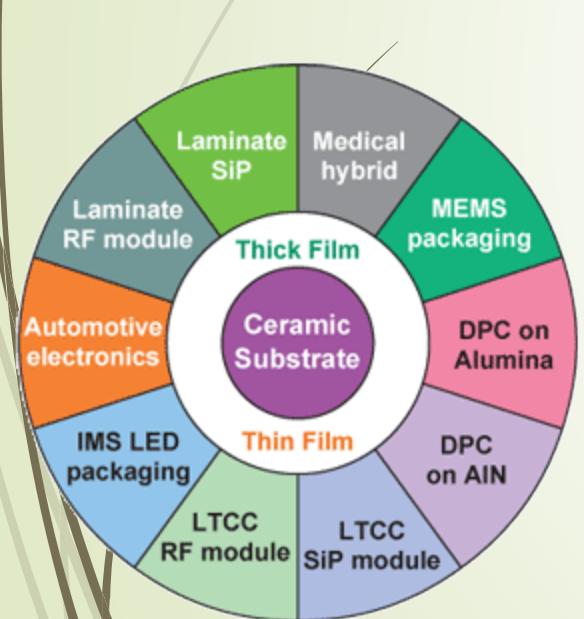
Serat kasa suatu screen terbuat dari yang umum digunakan adalah polyester, nylon dan stainless steel. Umumnya bahan screen yang digunakan dalam proses teknologi ini adalah stainless steel.

Material



2. Substrat

Substrat merupakan tempat jalur interkoneksi rangkaian serta tempat interkoneksi antara divais aktif maupun pasif.

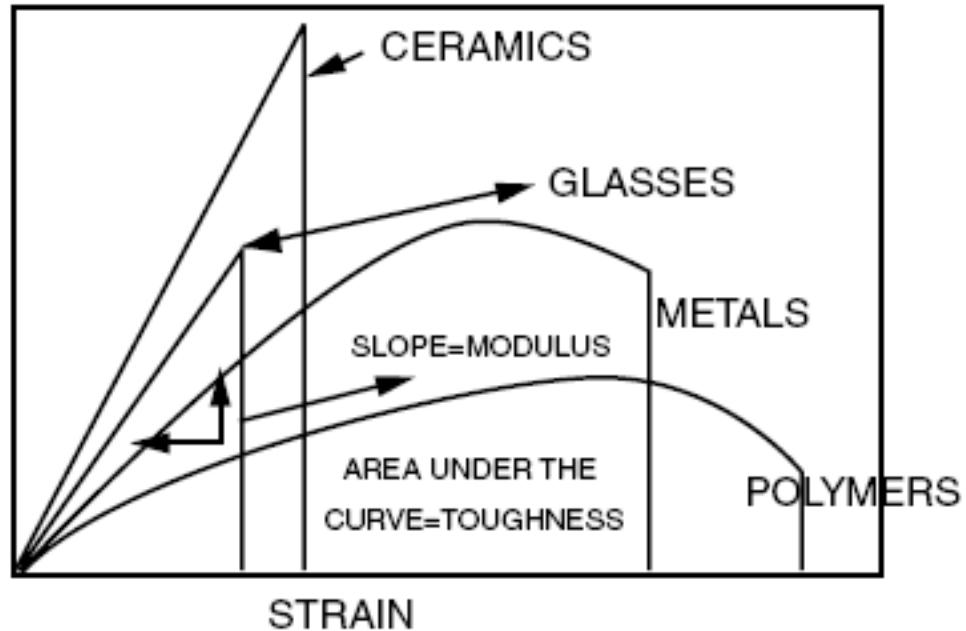


Fungsi Substrat dalam rangkaian film tebal, yaitu:

1. Sebagai penunjang interkoneksi dan perakitan divais.
2. Sebagai isolator dan tempat pelapisan serta pembentukan pola jalur konduktor dan komponen pasif.
3. Media penyalur panas dari rangkaian.
4. Sebagai lapisan dielektrik untuk rangkaian-rangkaian frekuensi tinggi.

Sifat Bahan

STRESS

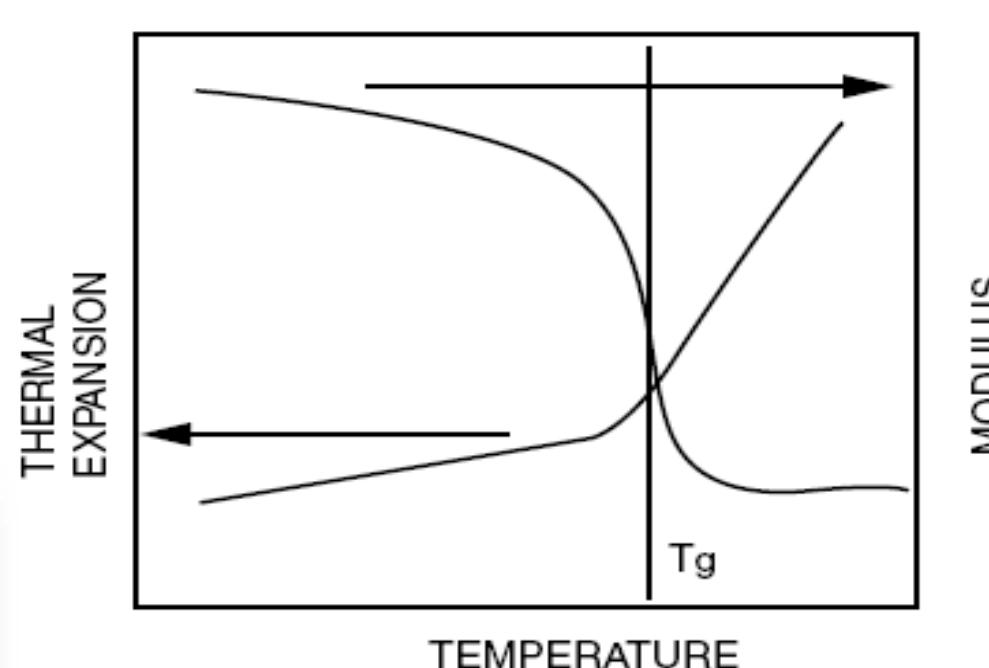


$$\frac{Q_x}{A} = -K_x \frac{dT}{dx}$$

$$CTE = \frac{dl}{l \, dT}$$

Sifat Substrat:

1. Kestabilan dimensi
2. Tahan terhadap gesekan
3. Konstanta dielektrik yang rendah
4. Permukaan rata dan halus
5. Stabilitas kimia terhadap pasta
6. Penghantar panas yang baik
7. Daya serapnya rendah
8. Jenis isolator yang baik



Glass transition temp. phenomena in polymers.

Material

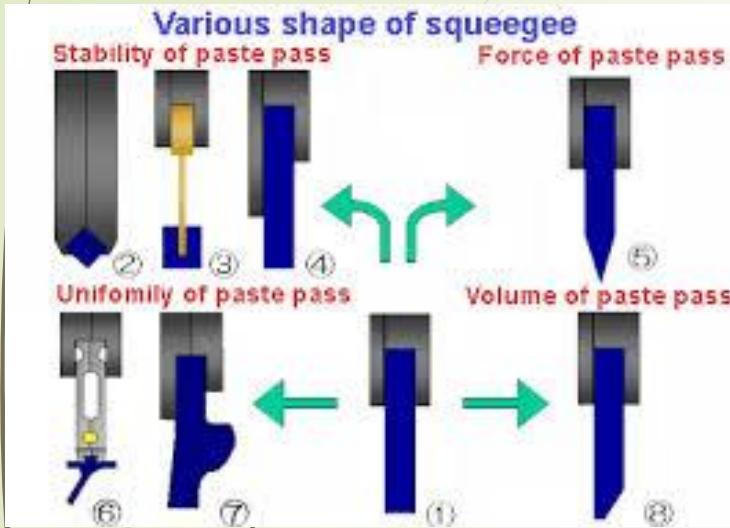


3. Pasta

Macam pasta yang diperlukan dalam pembuatan rangkaian elektronika teknologi hibrida film tebal adalah :

- Pasta konduktor, mempunyai sifat yang berguna untuk solder (bonding)
- Pasta resistor dengan berbagai nilai resistansi
- Pasta dielektrik yang mempunyai berbagai konstanta dielektrik dan karakteristik frekuensi.
- Pasta pelindung (coating), digunakan untuk melindungi rangkaian akhir
- Pasta solder.

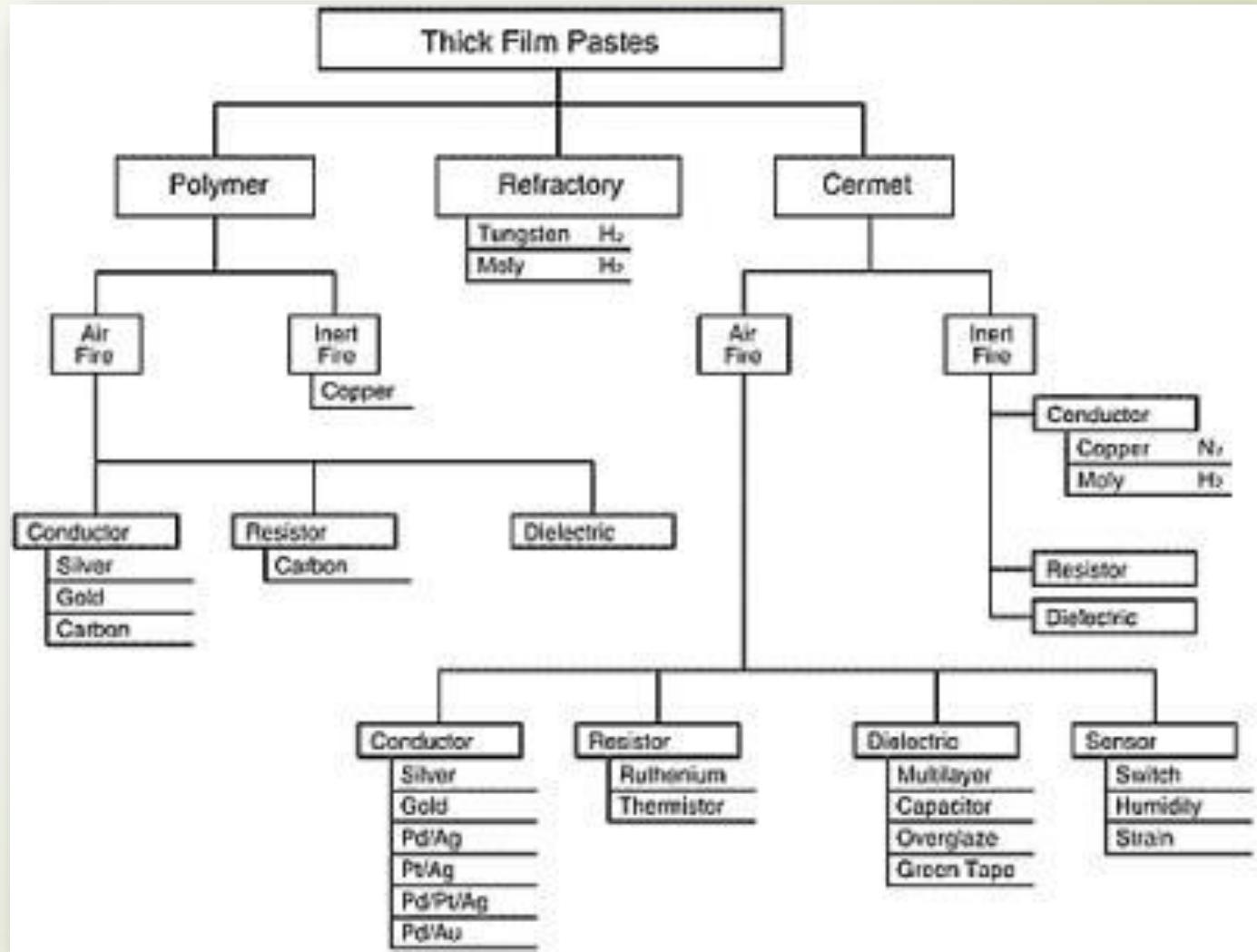
Material



► 4. Rakel

Rakel (squeegee) berfungsi untuk mengalihkan pasta ke substrat dengan cara menekan pasta ke dalam screen. Tegangan permukaan akan menahan pasta pada substrat saat posisi screen kembali ke keadaan semula. Bahan yang digunakan sebagai rakel adalah neoprine, polyrethana dan Viton® dengan kekerasan bahan antara 50-60 durometer. Posisi rakel harus menjadikan sisi tajam membentuk sudut 45 sampai 60 terhadap permukaan screen. Tekanan rakel terhadap screen akan berpengaruh terhadap hasil cetakan. Bila tekanan terlalu ringan maka pasta yang akan dilewatkan screen sangat sedikit.

Pasta Film Tebal



Pasta

Resistance pastes

| Paste | Conductive phase | R [Ω/sq] | TKR [10 ⁻⁶ /K] |
|---------|------------------|--------------------------|---------------------------|
| FK9921m | AgPd | 0,1 | ± 100 |
| FK9931m | AgPd | 1 | ± 100 |
| FK9941m | AgPd | 10 | ± 100 |
| FK9606 | RuO ₂ | 6 | ± 200 |
| FK9611 | RuO ₂ | 10 | ± 100 |
| FK9615 | RuO ₂ | 50 | ± 100 |
| FK9621 | RuO ₂ | 100 | ± 100 |
| FK9631 | RuO ₂ | 1000 | ± 100 |
| FK9632 | RuO ₂ | 2000 | ± 200 |

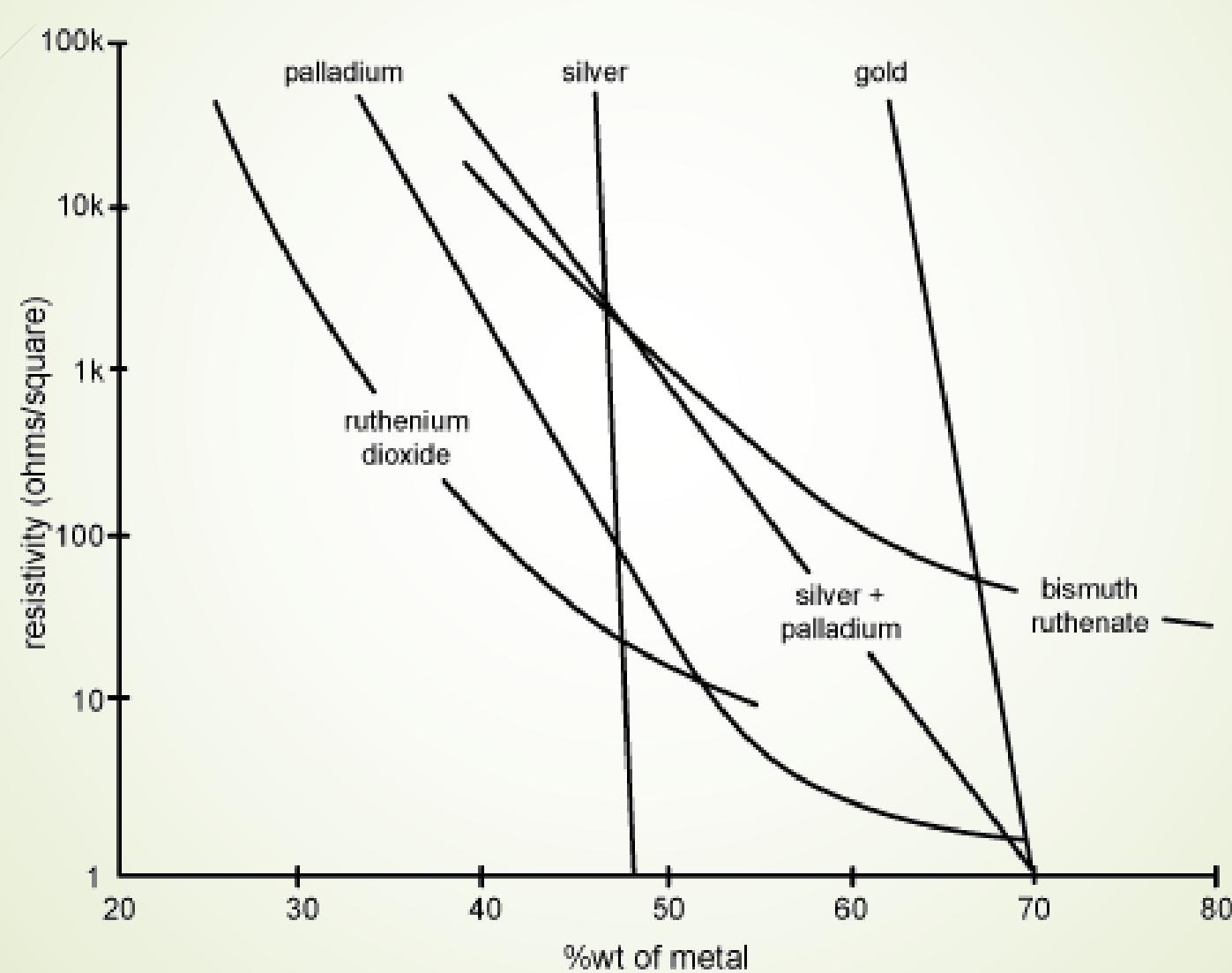
Glass pastes

| Paste | Application |
|---------|----------------------|
| FK4027 | Cover, 650 °C |
| FKM4889 | Marking paste, green |
| FKM4891 | Marking paste, white |
| FKM4893 | Marking paste, black |
| FKM4839 | Marking paste, red |

Conductive pastes

| Paste | Conductive phase | R [$m\Omega/\text{sq}$] | Application |
|---------------|------------------|---------------------------|---------------------|
| FK1205 FK1220 | AgPd | < 25 | resistance contacts |
| FK1071 | AgPt | < 6 | low resistance |
| FK1282 | AgPt | < 35 | very good liability |

Karakteristik sheet resistivity pasta konduktor (fired)



Material Organik

materials make for excellent insulators

Widespread use in electronics because of their low cost, good dielectric properties, reasonable mechanical properties and ease of processing

TABLE 18.4 Properties of important organic materials in electronics.

| Polymer/Polymer Composite | Relative Dielectric Constant | Thermal Expansion Coefficient [ppm/ $^{\circ}$ C] | Approximate Processing Temp [$^{\circ}$ C] |
|----------------------------|------------------------------|---|---|
| Epoxy-Kevlar (x-y) (60%) | 3.6 | 6 | 200 |
| Polyimide-quartz (x-axis) | 4.0 | 12 | 200 |
| FR-4 (x-y plane) | 4.7 | 16 | 175 |
| Polyimide | 3.5 | 50 | 350 |
| Benzocyclobutene | 2.6 | 35–60 | 240 |
| BT (Bismaleimide triazine) | 3.5 | 50 | 220 |
| Poly norbornene | 2.47 | 80 | 250 |
| Cyanate ester-based | 2.8 | 62 | 220 |
| Teflon™ (DuPont Co.) | 2.2 | 20 | 400 |

Proses

Typical thick-film process

Preparation

Component assembly

Screen-printing

Separation of elements

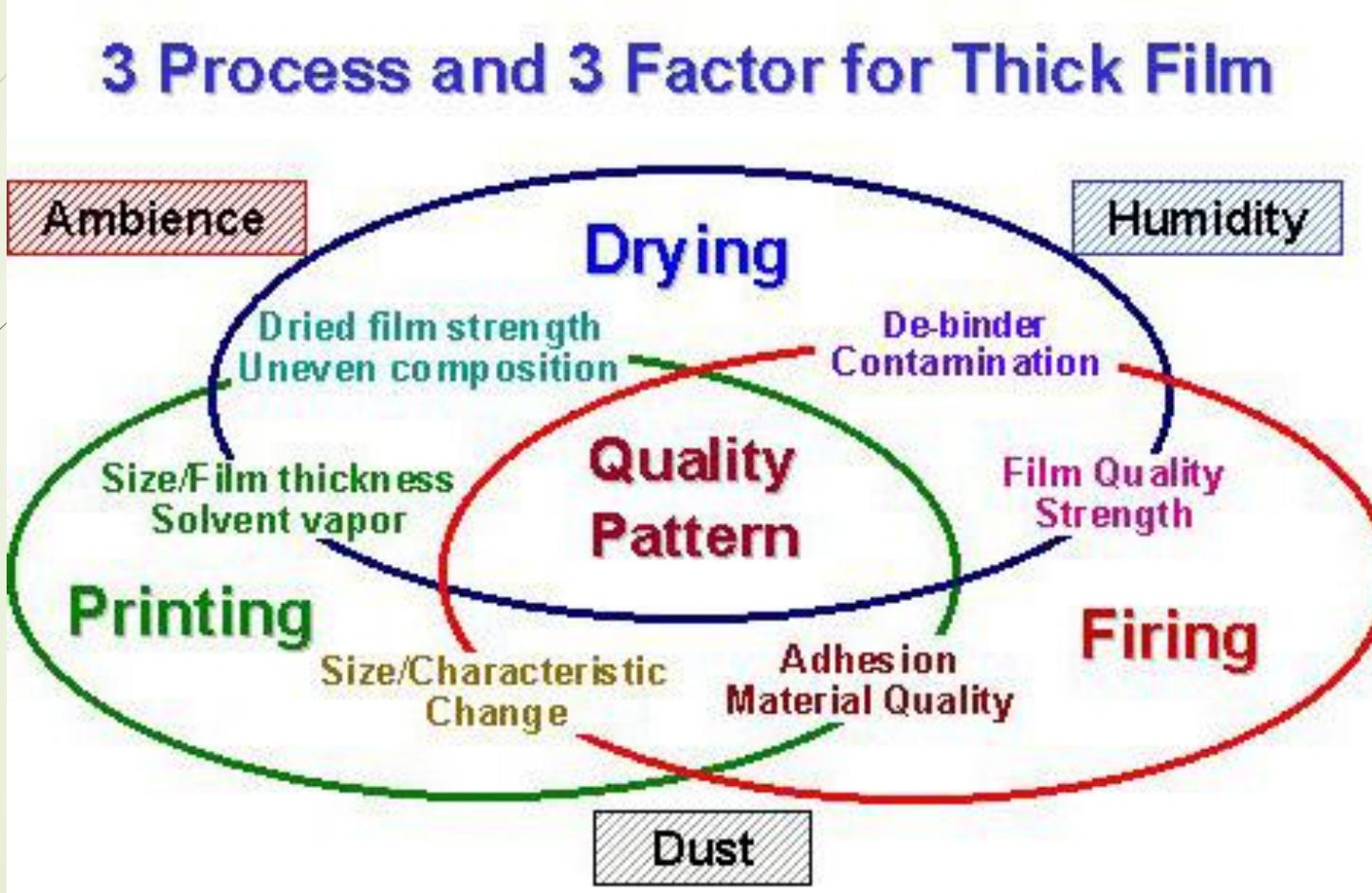
Drying/curing

Firing

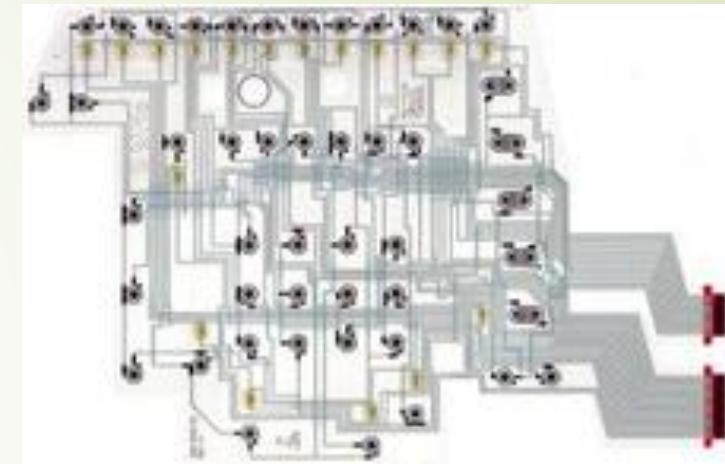
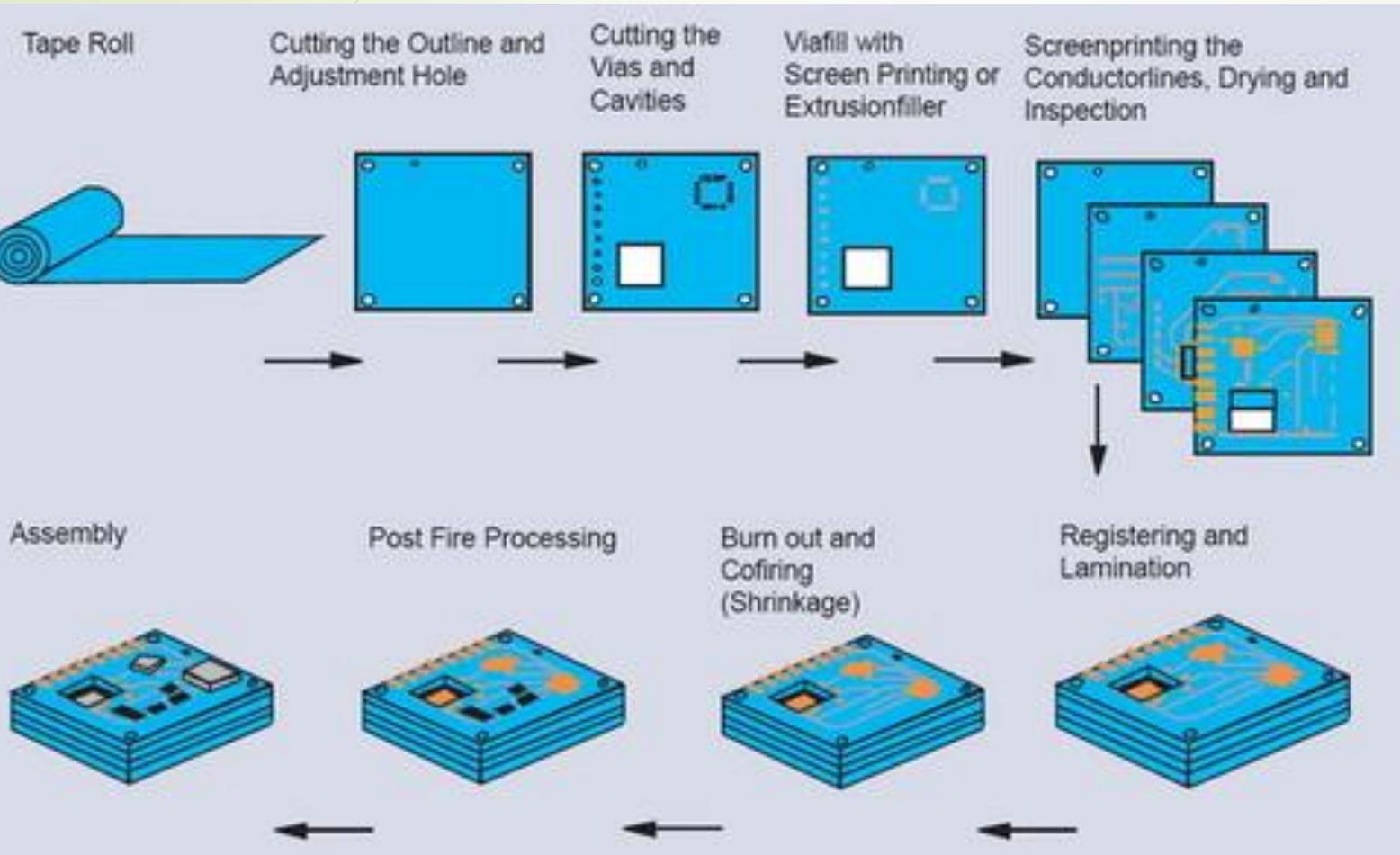
Benefits of thick-film technology

- Reduced physical board area
- High component densities
- Excellent reliability
- Excellent heat transfer
- Consistent performance

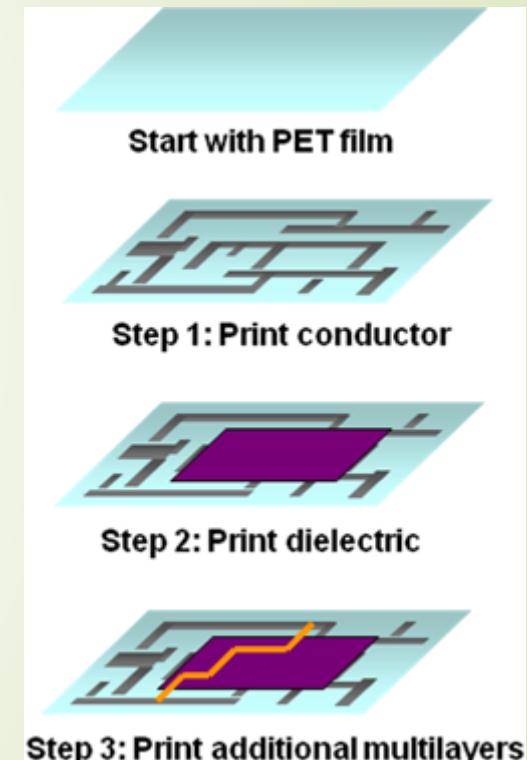
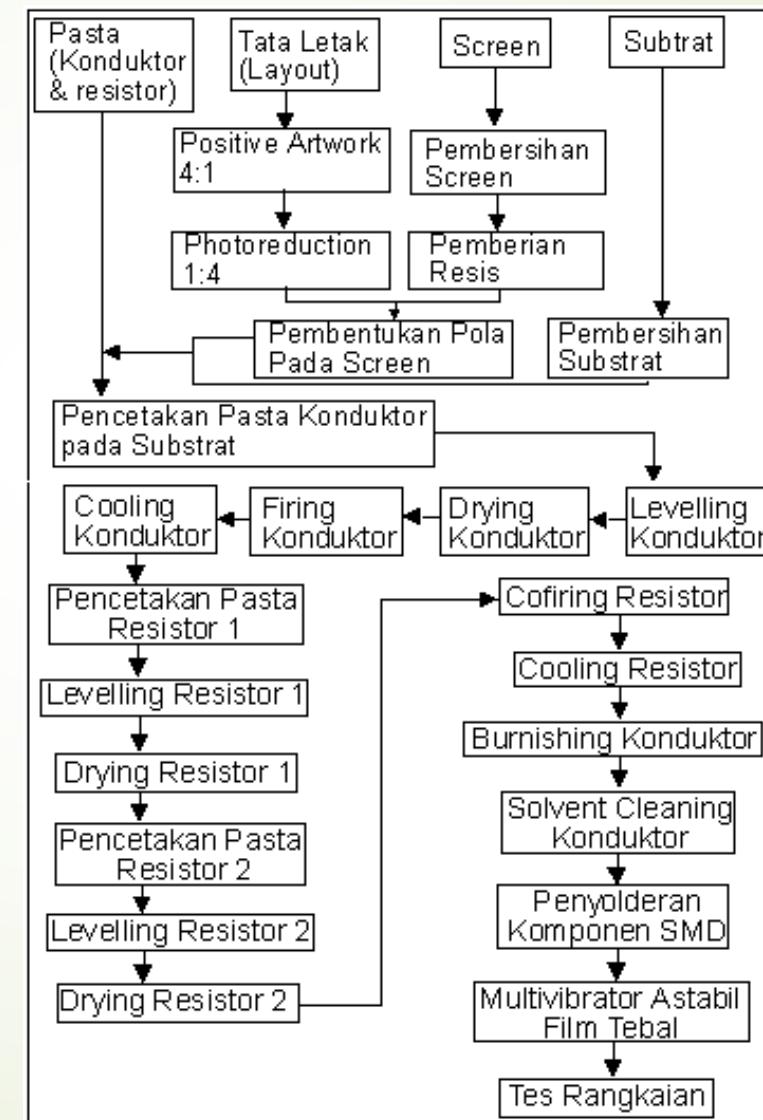
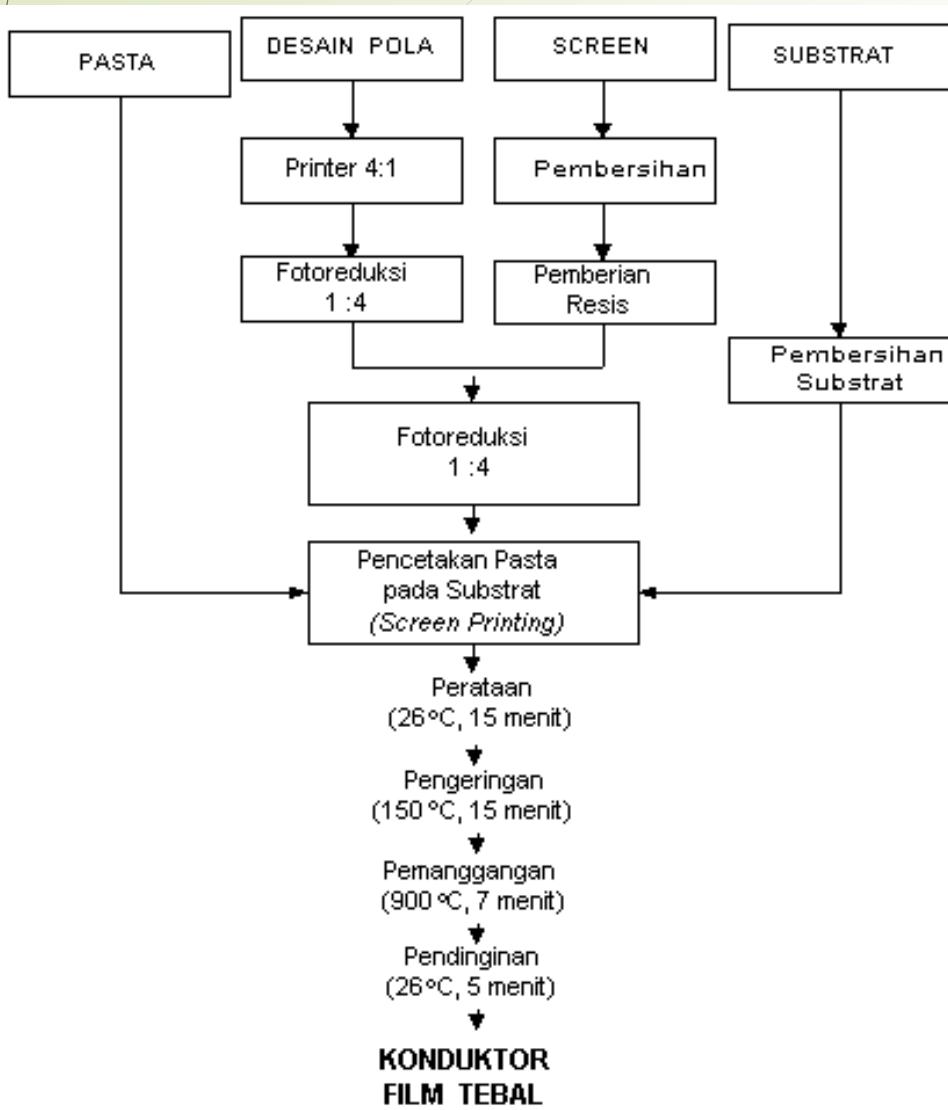
Faktor & Proses Film Tebal



Proses Fabrikasi



Contoh Proses



Teknik Deposisi

Beberapa teknologi untuk deposisi pasta:

- Screen /stencil printing
- Aerosol printing
- Inkjet printing
- Stamp printing or gravure printing..

Technical equipment

Development of thick-film pastes

- dispersing (mills, dissolver, roll mills)
- Rheometer
- Screen printer for planar and tubular substrate geometries
- Centrotherm furnaces (air and nitrogen), batch-ovens PEO 601

Karakterisasi Lapisan

- **Ofilometer** for planar and tubular substrate geometries
- **REM,EDX,FIB**-preparation
- In situ measurements (resistance, heating microscopy, chemical reactivity)
- Pull/shear tester DAGE
- Resistance measurements, soldering and bonding technology, infrared measurement, electrochemical sensor measurement, impedance measurement
- Temperature, air-conditioning and thermal shock chambers for reliability studies



Technology

- Screen Printing
- Viscometry
- Drying and Firing
- Thickness measurement
- Electrical Measurement
- Resistor trim

Screen Printing

- Presco 435 Screen-Printer



1 mil alignment accuracy

Viscometry

- Viscometer digunakan untuk mengecek viskositas pasta



Tank Viscometer



Stabinger viscometer



Rheometer

Drying Furnace Firing Furnace

- Drying furnaces are used to dry the paste prior to firing. The thickness should be measured after drying.
- Firing furnace sinters (fuses) particles together.



Belt speed and heater temperature sets the profile.

Thickness measurement

- Profilometer – uses a stylus to trace the thickness profile of a printed line.

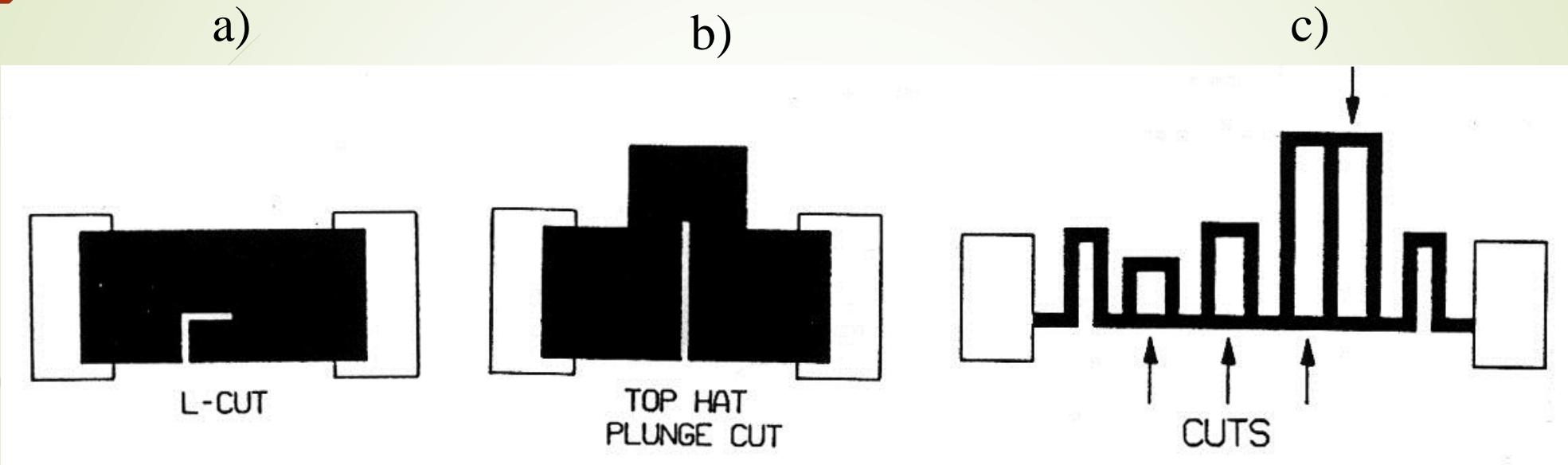


Resistor Trim

- Uses an infra-red laser to trim through a printed resistor – x,y trim stage.



Laser trimming

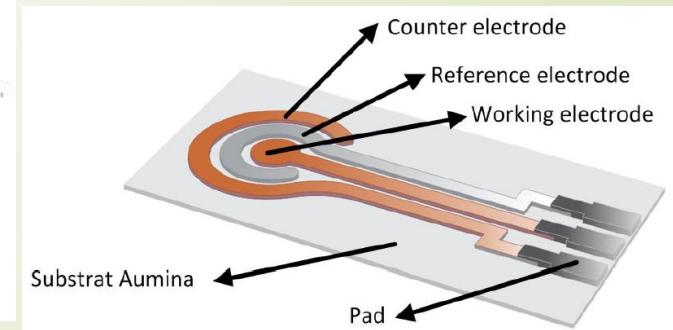
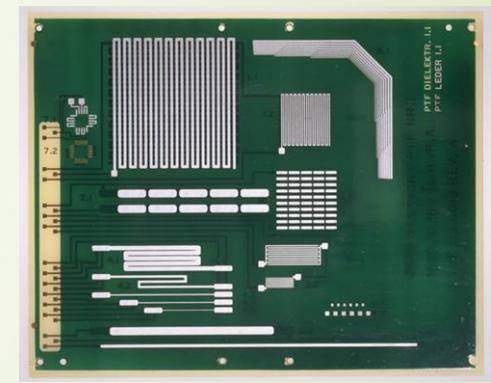
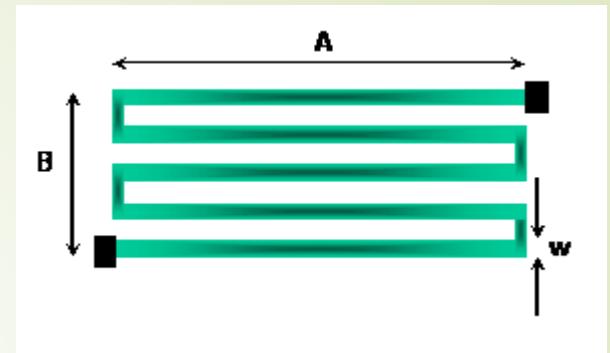
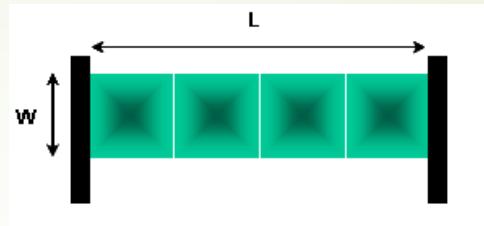
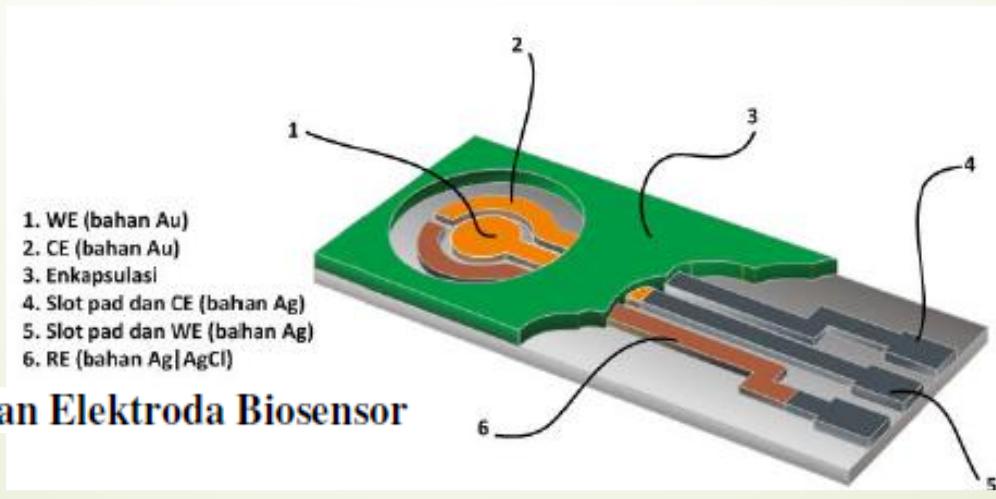


Bentuk Potongan Trim Laser:

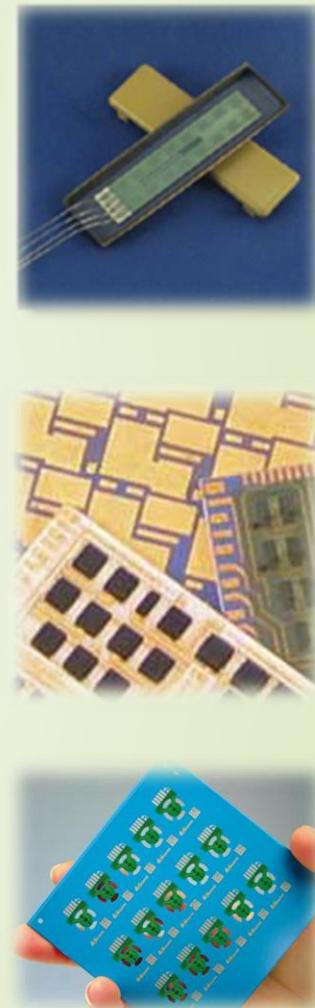
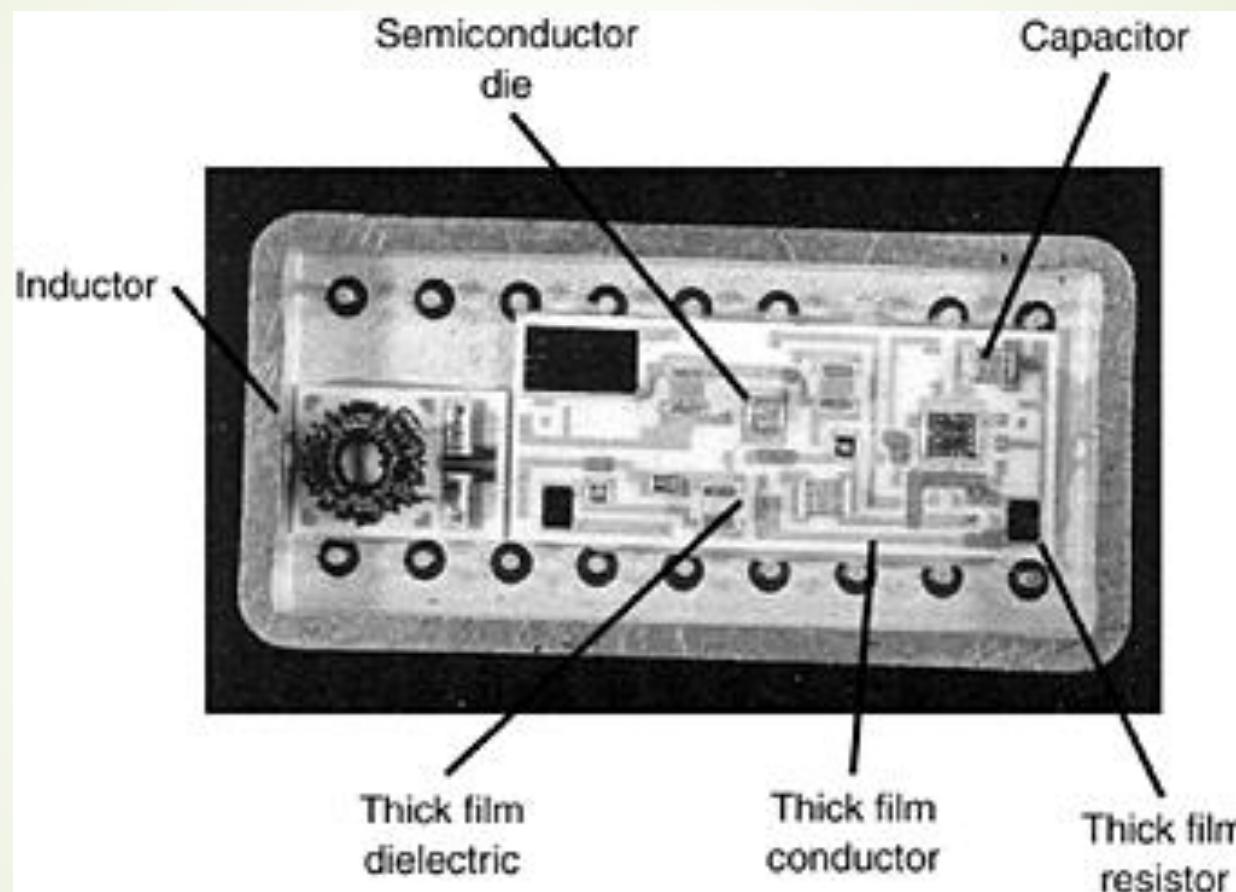
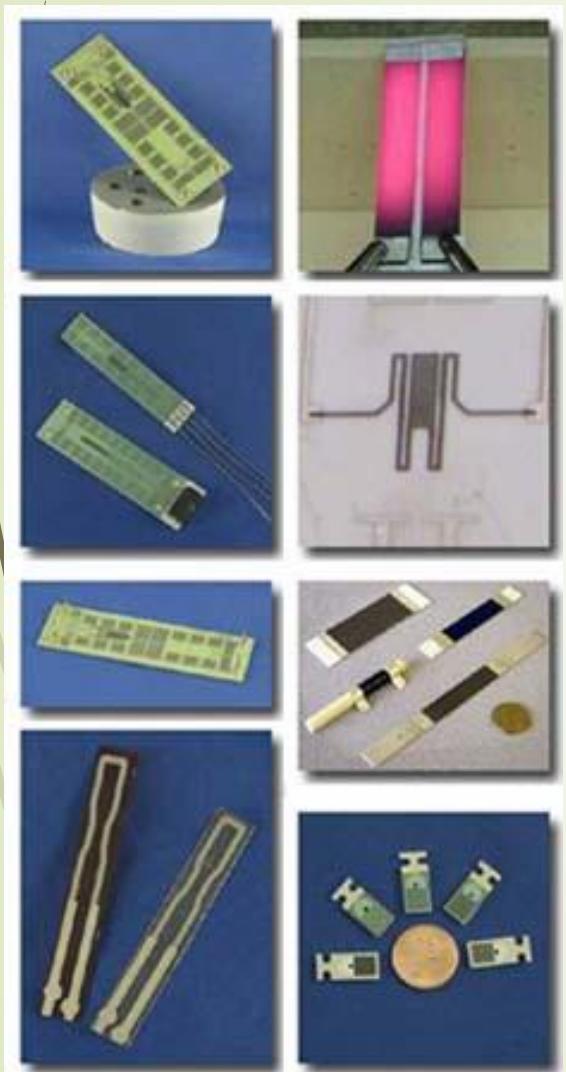
- a): L-cut
- b): Top hat plunge cut
- c): Digital trimming, which is most used for high precision thin film resistors

Aplikasi Film Tebal

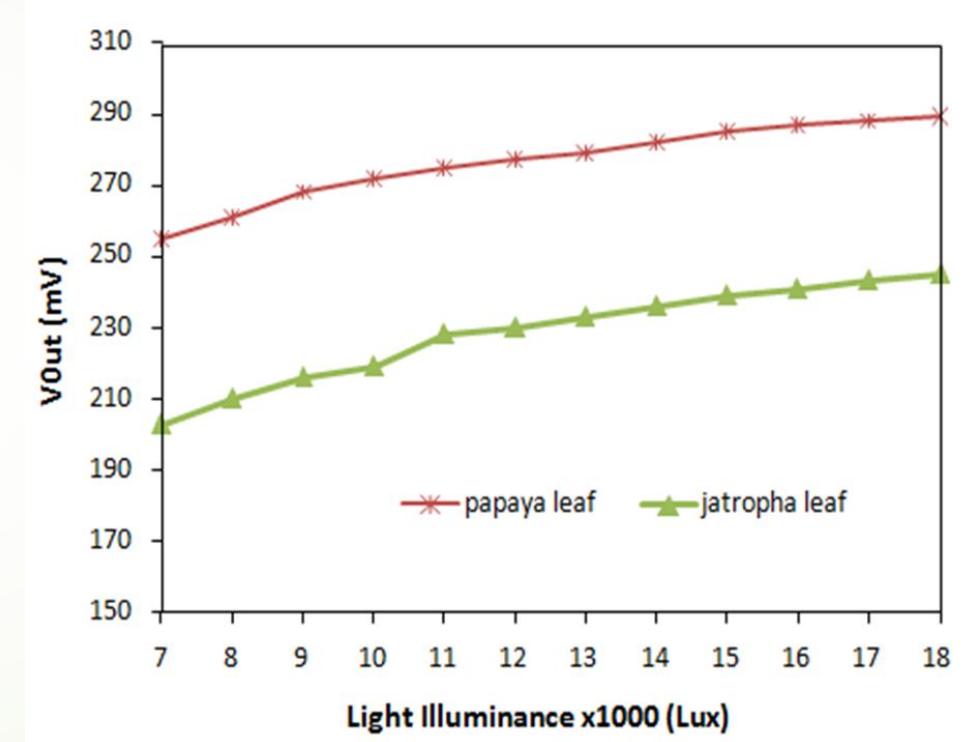
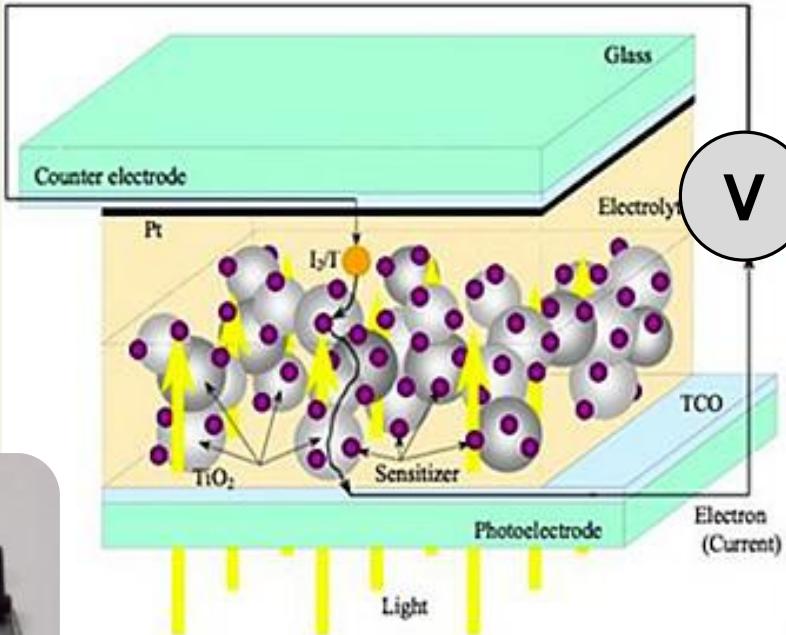
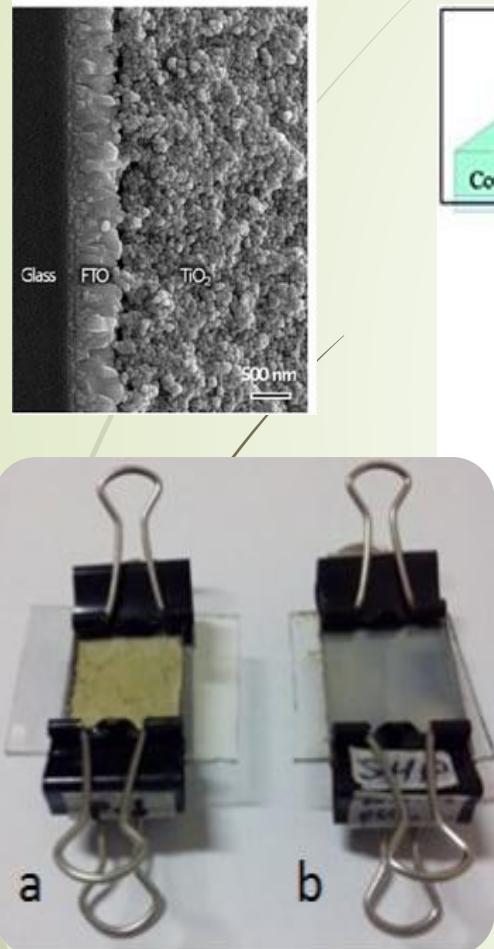
- ▶ Resistor
- ▶ Kapasitor
- ▶ Induktor
- ▶ Sensor
- ▶ Elektroda
- ▶ Solar Sel
- ▶ Display



Aplikasi



Chlorophyll extraction of papaya and jatropha leaves in DSSC



Sholeh HP, Eka Maulana, et.al. Organic Solar Cell in DSSC 2013

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