Embedded PCB Trimmer 개발

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Embedded PCB Trimmer Development

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Location : 코엑스 컨퍼런스센터 402호
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EOTECHNICS

Introduction

EOTECHNICS

▶ Resistor & capacitor 와 같은 수동소자 는 필연적으로 아래의 표에서 표현하고 있는 요인 들로 인해 non-uniformity를 갖는다. 따라서 저항이나 capacitor를 형성할 때 목표했던 저항 값이나 capacitance를 구현하지 못하는 것이 일반적이다. 이 때, 원하는 저항 값 또는 capacitance 값을 맞추기 위해 resistor나 capacitor의 특정 부위를 없애주는 공정이 trimming이다. 기존의 mechanical abrasive 방식을 대체하고 있는 Laser trimming은 저항 편차를 기준으로 1 %, 정밀도로 맞출 수 있다.

Resistor Type	Sheet R'	Thickness	Resistor Geometry	Copper Geometry	Total
Polymer Thick Film	1 %	5 %	1 ~ 5 %	5 %	12 ~ 16 %
Metal Thin Film	1 %	3 %	1 ~ 5 %	5 %	10 ~ 14 %
Thin Film on Foil	1 %	1 %	1 ~ 5 %	5 %	8 ~ 12 %

*G. Lucas, "Fundamentals of Buried Passive Components."
IPC Annual Meeting (Orlando, FL), October 2001.

Introduction

EOTECHNICS

▶ 수동소자를 PCB에 기판에 내장하여 전기적 특성과 신뢰도 극대화 가능

▶ 수동소자로 인한 소음, 신호처리 지연등 감소

▶ 기판표면에 수동소자가 차지하던 면적을 줄일 수 있어 같은 크기의PCB기판에 보다 많은 양의 능동소자를 실장 할 수 있다(system의 크기를 30%이상 축소가능).

▶ 각종 통신기기, 디지털가전, 이동통신단말기 등에 적용하여 차세대 PCB로 제품 크기의 축소 한계 극복

▶ 외 층에 사용하는 solder량 감소로 인하여 자연적으로 환경친화적인 Pb Free 정책과 부합

Introduction

EOTECHNICS

▶ 서버용 임베디드 기판, 임베디드 메모리모듈 기판, 시스템인패키지(SiP)와
통신용 다층 기판 (MLB)을 중심으로 한 MP3폰, 디지털 카메라 폰 등의 초소형,
다기능 전보기기용 PCB등으로 그 적용 영역이 점차 확대될 것으로 전망.

▶ 최근 네트워크를 비롯한 IT기술의 급격한 발전으로 초고속화, 초소형화, 다기능화에 대한
수요가 증대됨에 따라 일부 부품을 PCB상에서 제거하거나 다층 PCB에 내장시켜야 할 필요성
때문에 임베디드 PCB의 시장규모가 현재 미미한 수준이지만, 향후 완제품의 초소형화,
초고속화 추세에 따른 수요가 급성장할 것으로 전망.

Embedded PCB Trimmer (MAIN)

EOTECHNICS

▶Passive Trimming

- Typical laser trim method
- Involves removal of material from a resistor to increase its resistance.
- Monitoring parameter is resistance & capacitance itself.

▶Active Trimming

- Involves removal of material from a resistor to change a circuit parameter.
- Called functional trimming : the circuit is functioning during the trimming process.
- Parameters monitored are ACV, DCV, ACI, DCI, FREQUENCY.
- Active is usually to a circuit voltage output.

Embedded PCB Trimmer (Schematic)

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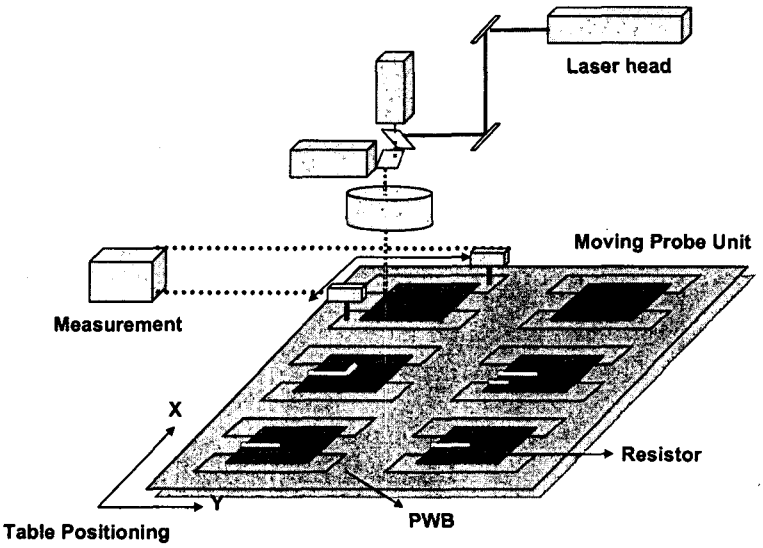

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Trimming method 1

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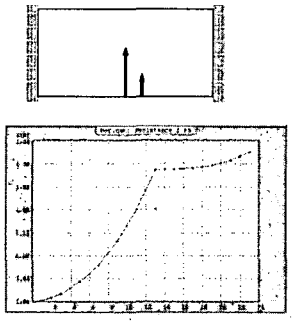
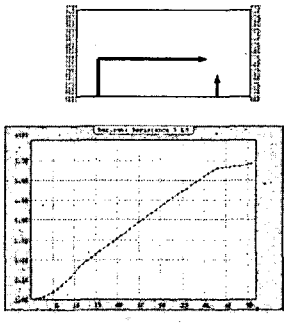
< Plunge cut >



- Medium value change
- Good accuracy

< L- cut >



- Medium high value change,
10~60% range of adjustment

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Trimming method 2

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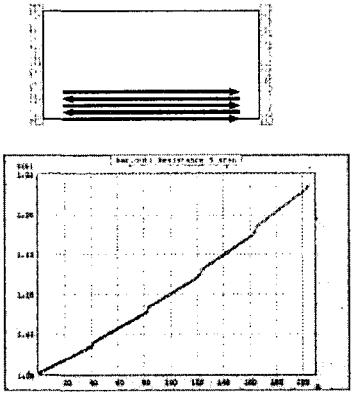
< Scan cut >



< Serpentine cut >

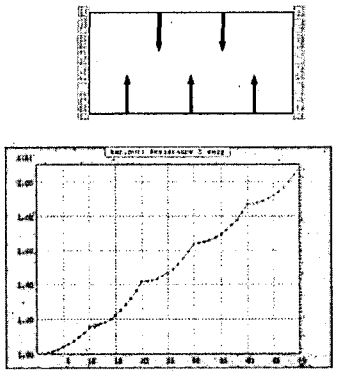


Photo Courtesy of Konzipieren und Bewerten von Hochpräzisions-Hybridwiderständen durch Laser-Trimm-Simulation

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SMT VS Embedded component

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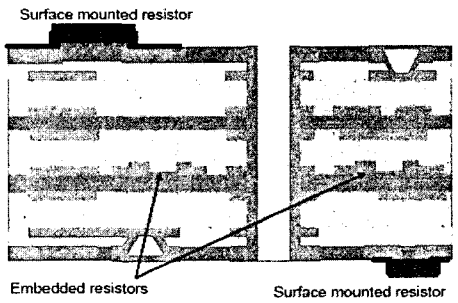

Embedded Components:

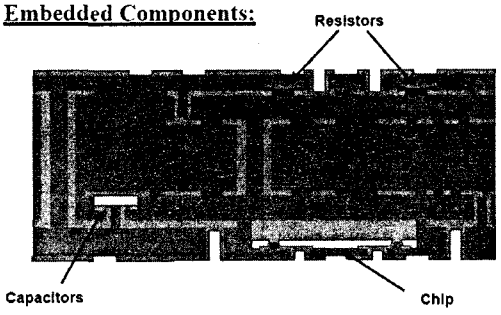

Photo Courtesy of Circuitree

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Resistor material

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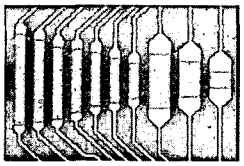
▶ MATERIAL CHARACTERISTICS

- Ultra thin (0,04µm...0,4 µm)
- Three major solutions

1.NiP resistive alloy is electrodeposited on a Cu foil;
continuous "roll-to-sheet" electro-chemical plating
2.NiCr or NiCrAlSi alloy are sputtered on a copper foil
3.Pt + doping is coated using Combustion Chemical Vapor Deposition (CCVD) -method

▶ Summary



- Easy to fabricate
- Limited in resistance range
- Very high values can not be embedded
- Good reliability properties
- Cost is high
- Best technology for high-end products with relatively low volumes

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Resistor material

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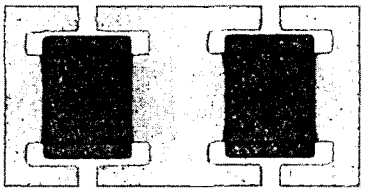
▶PTF – MATERIAL CHARACTERISTICS

- Screen printable paste (PTF = Polymer Thick Film)
- Printed thickness 10µm...20µm
- Carbon powders with polymer chains
- Curing in convection oven or in infra-red oven



▶SUMMARY

- Easy to fabricate
- Very wide resistance range
- All the values can be embedded
- Reliability is good, but worse than with thin films
- Cost is low

Best technology for high volume products with tight cost frames

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Resistor material

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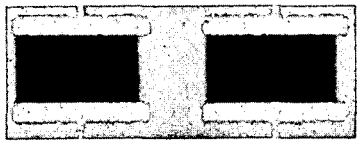
▶ **Ceramic thick film**

- Very stabile resistors
- Complicated process
- Not commercial today

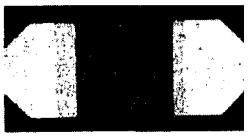
Best material for high-end products



▶ **Plated thin film**

- Easy process
- Limited sheet resistivity

Best material for special applications



EPT Development

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▶ **High speed processing**
- **Diode pumped solid state laser**
- **High speed Scanning System**
- **Stability :below 5%**

▶ **Fully automatic handing system**
- **High speed X-Y moving stage**
- **Auto loading / unloading**
- **Up to 610 x 510mm (24" x 20")**

Embedded PCB Trimming System

▶ **Flying type moving probe**
- **Full Kevin type (2 moving probe)**
- **Min. pad size : 300um**

▶ **High accuracy measurement**
- **Software-enhanced, forced current/measure voltage**
- **0.01Ω ~ 1MΩ**

Embedded PCB Trimmer

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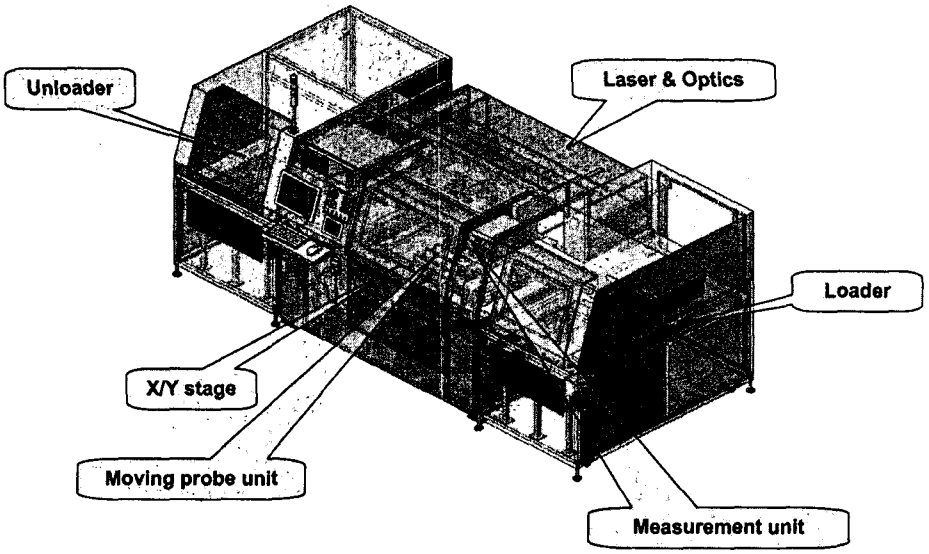

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Optics & laser parameter

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1. Rayleigh Range (Depth of Field)
   - o $d_f = \pm \pi w_0^2/\lambda$
   - o So as $\lambda \rightarrow 0$, $d_f \rightarrow \infty$

2. Smallest Theoretical Spot Size
   - o $d_{dl} = 1.27\ \lambda f M^2/D$
   - o So as $\lambda \rightarrow 0$, $d_{dl} \rightarrow 0$

3. Peak Power = Pulse Energy per Pulse Duration

4. Power Intensity = Peak Power per Unit Area (spot size) on Target

5. Wavelength

6. Beam profile (TEM_{00}) Gaussian mode

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Absorption graph

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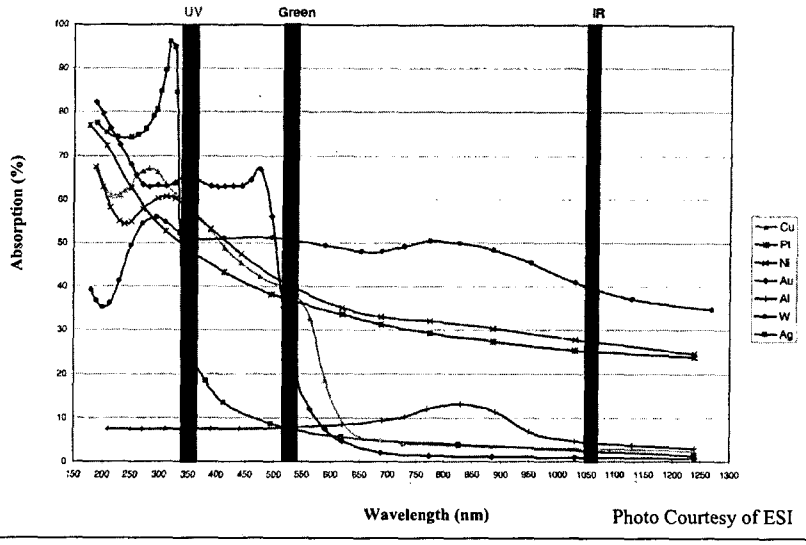

Photo Courtesy of ESI

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Laser beam mode

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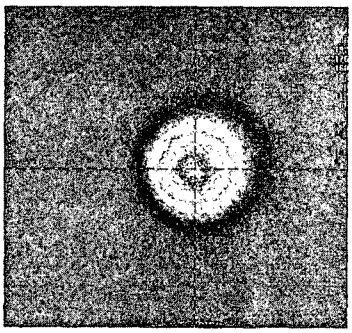

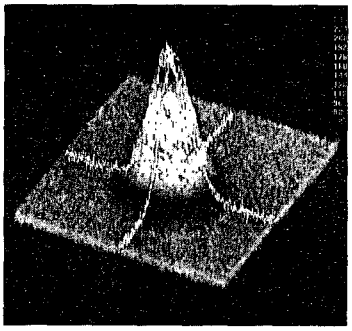

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Measurement (Kelvin)

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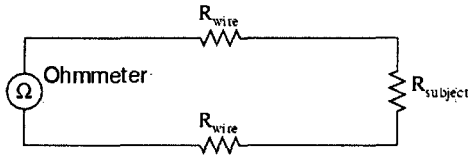
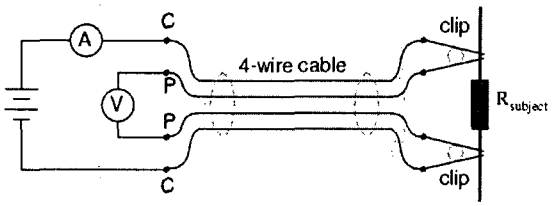


Ohmmeter indicates $R_{wire} + R_{subject} + R_{wire}$



$$R_{subject} = \frac{\text{Voltmeter indication}}{\text{Ammeter indication}}$$

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Measurement (Resistor)

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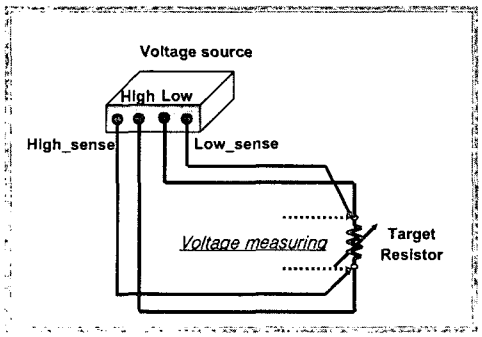

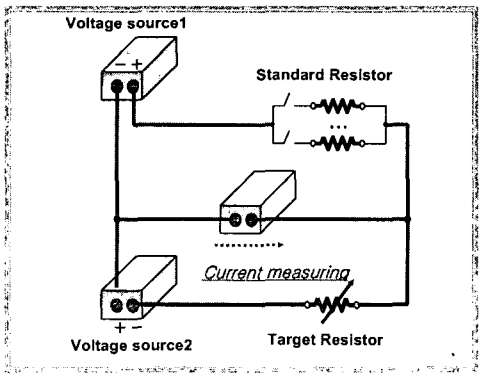

Voltage measurement & Current measurement comparison

[Voltage measuring]

- Easy to make

- Low resistance(under 10K ohm)

[Current measuring]

- Complex to make

- High resistance(over 10K ohm)

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Measurement (Capacitor)

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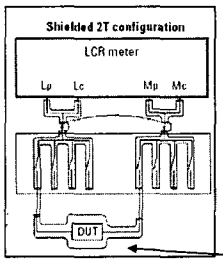
- Capacitor trim range : 10pF ~ 1F @1MHz
- Capacitor measuring offset between machine and standard measurement : 2pF 존재
- Capacitor trim tolerance : +/- 8% (but Min.1pF)

Table 1. Cable configurations

		Measurement frequency range	
		Typically 100 kHz and below	Typically 100 kHz and above
Impedance range	Low impedance (typically 100 ohm and below)	4-terminal pair (4TP)	4-terminal pair (4TP)
	High impedance (typically 100 ohm and above)	4-terminal pair (4TP)	Shielded 2-terminal (2T)



Limitation of Optimized System:

- End side of cable for measurement : Shield cable.
- Cable length : Must be minimized.
  : Must be fitted requirement condition of measurement equip.

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Moving probe unit VS Fixed probe unit

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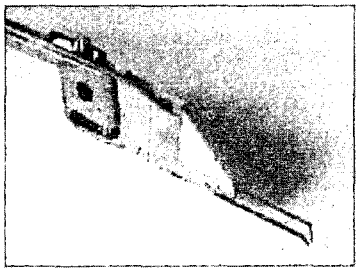

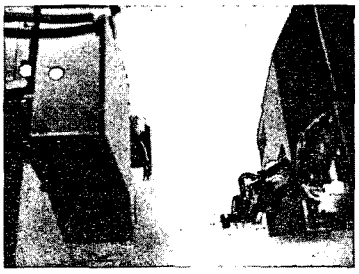

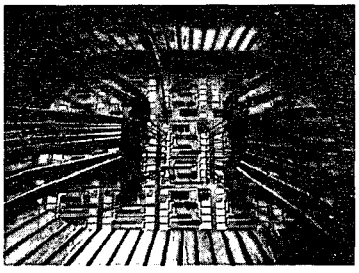

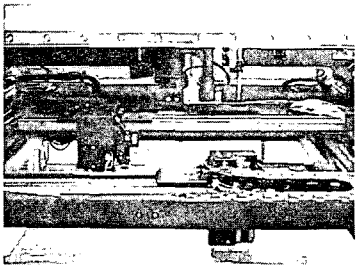

Photo Courtesy of GSI

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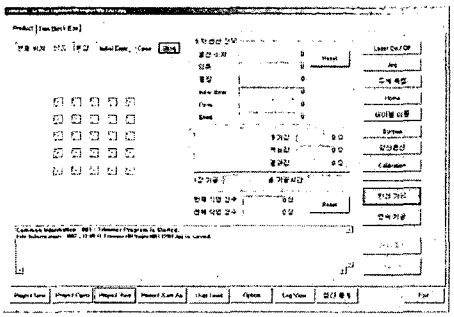
Moving probe unit VS Fixed probe unit

EOTECHNICS

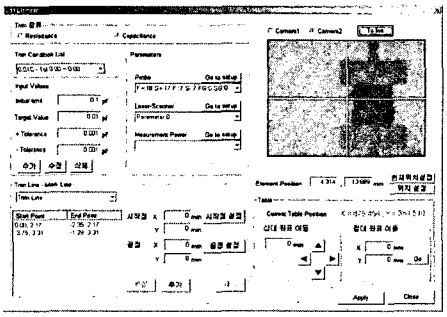
1. A systematic, regular x-y layout of test pad is preferred in fixed probe unit.
2. Irregular layout of test pad could be trimmed in moving probe unit.
3. Probe access to the test pads should not hinder laser view in fixed probe & moving probe unit
4. Moving probe speed & accuracy is rapidly increased.
5. Fixed probe unit need to check the laser view hindrance.

Embedded PCB Trimmer (S/W GUI)

EOTECHNICS



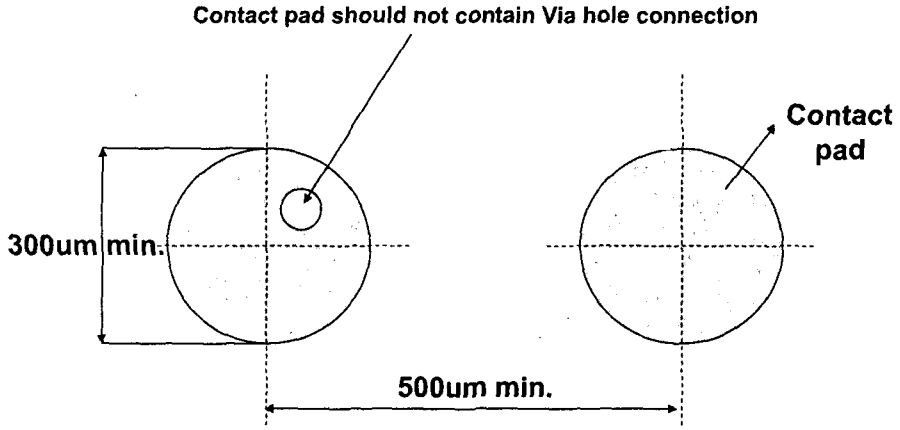
Main Window



Job Editor Window

Contact

EOTECHNICS



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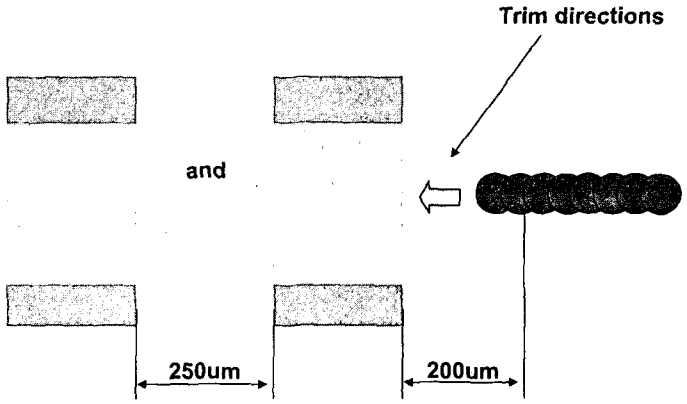
Resistor pattern array distance

EOTECHNICS



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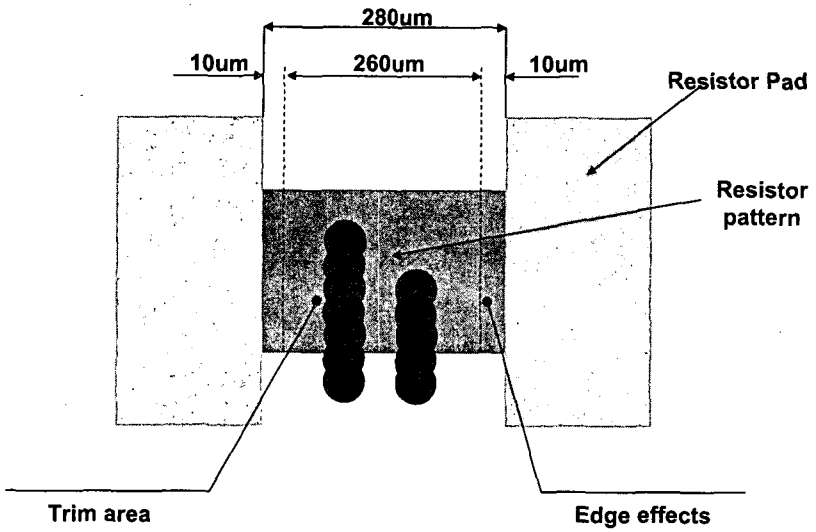
Resistor pattern geometry

EOTECHNICS



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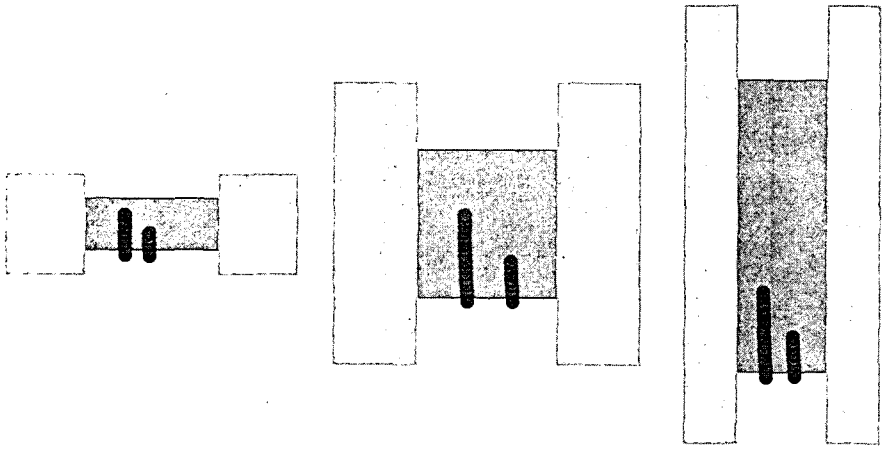
Desirable resistor pattern geometry

EOTECHNICS



Case 1
Resistor pattern X & Y axis size aspect ratio ≤1

Case 2
Resistor pattern X & Y axis size aspect ratio ≈1

Case 3
Resistor pattern X & Y axis size aspect ratio ≥1

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Resistor power

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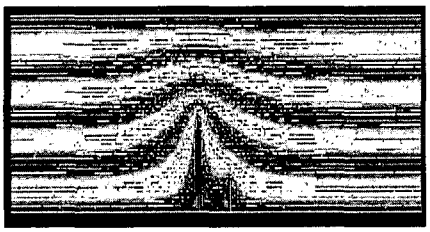
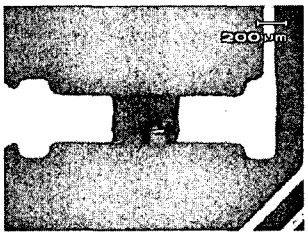
▶ Standard power value of resistors 0.25W or 0.5W are suitable.

▶ Some resistor material cannot endure power of resistance at measurement condition

$P = I^2 \times R$ where P = power developed in the resistor in watts (W)
I = current through the resistor in amps (A)
R = resistance of the resistor in ohms (Ω)
V = voltage across the resistor in volts (V)





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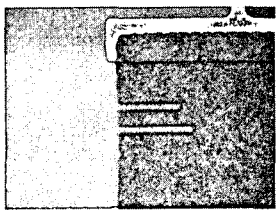
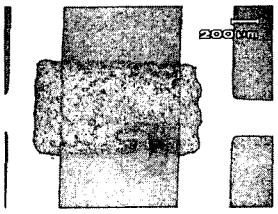
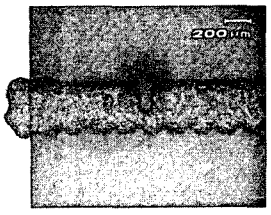
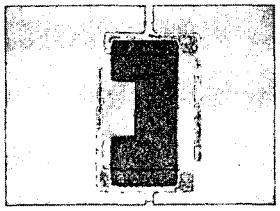
Sample image

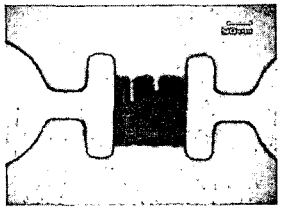
EOTECHNICS

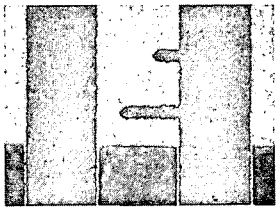












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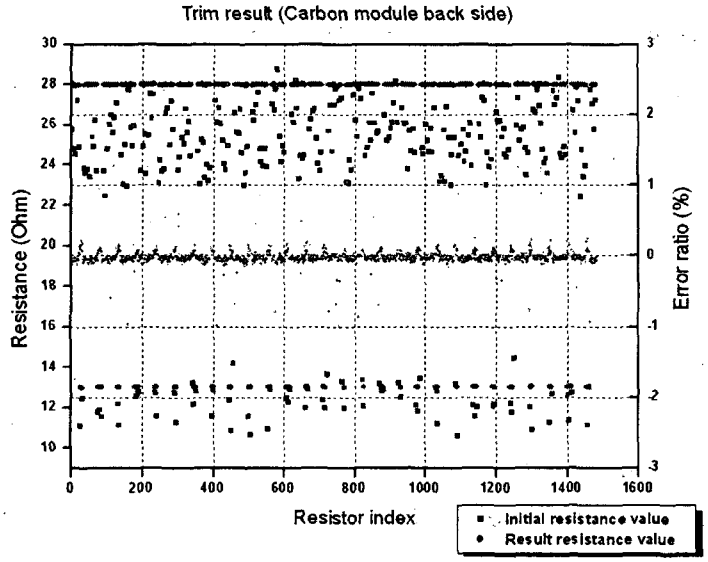
Sample result 1

EOTECHNICS



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Sample result 2

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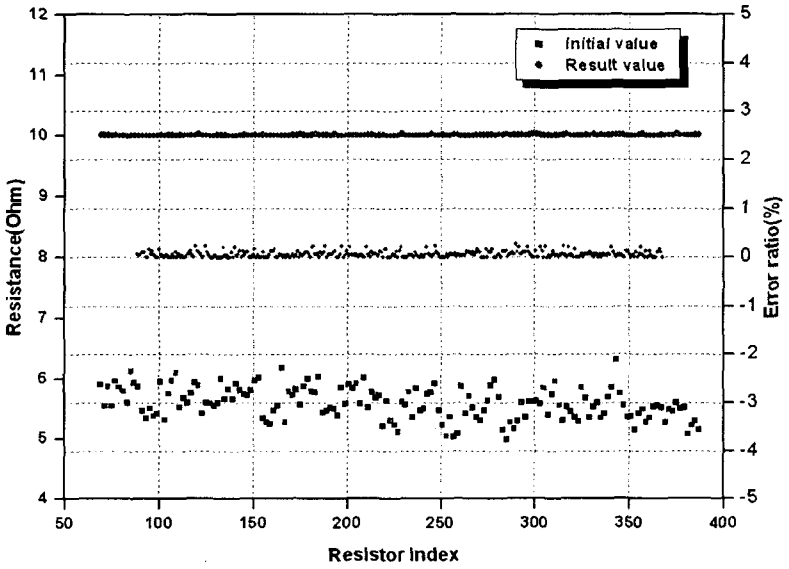

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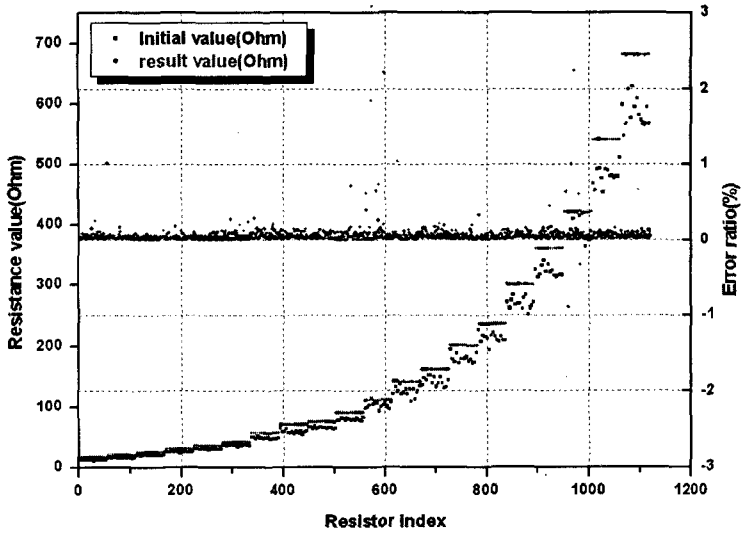
Sample result 3

EOTECHNICS



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Conclusion

EOTECHNICS

1. Combining laser optics technology with moving probe technology into embedded PCB Trimmer

2. This system can process large panel size embedded resistor PCB board with high speed & high accuracy within 1 % trim tolerance at mid range value.

3. Future work
   - Achieve capacitance trim
   - Small contact pad & Small resistor pattern size
   - Increase speed & accuracy

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