Manufacturing Technology for Platinum Resistance Temperature Detectors

inostek
INOSTEK Inc.
#707 Gyeonggi Technopark
1271-11 Sa 1, Sangnok,
Ansan, Gyeonggi 426-901, KOREA
Tel : 82-31-500-4110
Fax: 82-31-500-4112
http://www.inostek.com
E-mail: information@inostek.com

Temperature Sensors

- Non-contact type
  - Radiation temperature detector
  - Optical pyrometer

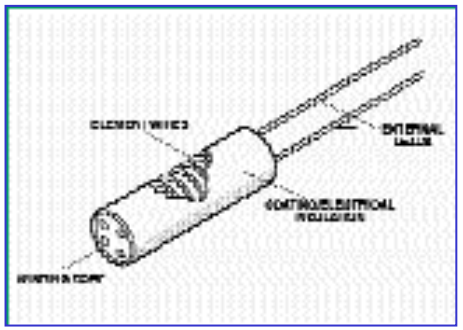
- Contact type
  - Thermistor
  - Resistance temperature detectors(RTD)
  - Thermocouple

Characterization of contact type temperature sensors

	RTD (Platinum RTD)	Thermocouple	Thermistor
Temperature Range	–200˚C ~ 850˚C	–190˚C ~ 1821˚C	0 ˚C ~ 300 ˚C
Accuracy	±0.001˚F to 0.1˚F	±1˚F to 10˚F	High
Response Time	Moderate	Fast	Fast
Stability	Excellent long-term stability	Poor stability	Good stability
Linearity	Best	Moderate	Non-linear
Sensitivity	High sensitivity	Low sensitivity	High sensitivity

Platinum RTD

Wire type

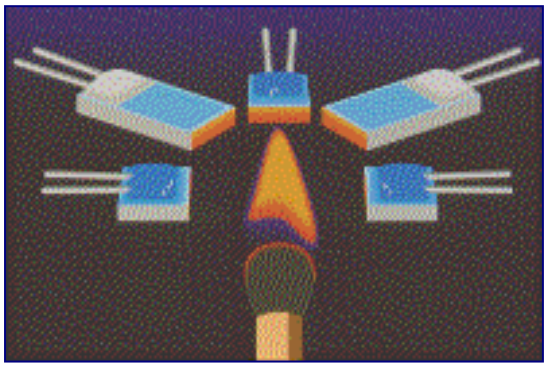


- standard PRTD
- accuracy
- high cost

Ceramic capsule type

- high endurance
- high cost
- late response

Thin film type



- moderate response
- small size
- good reproducibility
- good long-term stability
- low cost

Applications of Platinum RTD*

Monitoring of temperature
in device

RTD

Automotive
Heating/Air conditioning
Medical
White good
Electronics

dialysis systems
incubators
centrifuges
gas chromatographs

Engine management
exhaust gas monitoring
air volume measurement
thermomanagement of engine oil.

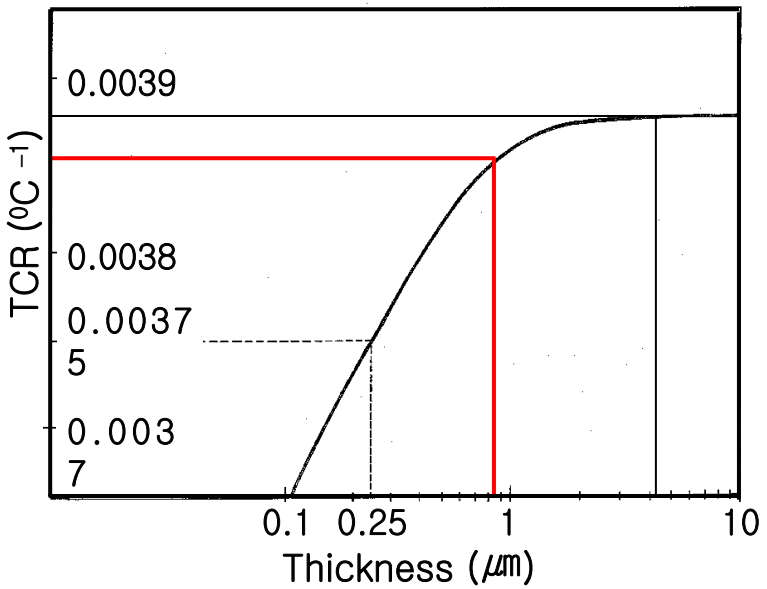
SMD components

heating
ventilation
air conditioning

* Ref. : http://www.heraeus-sensor-nite.de

TCR vs. Platinum film thickness

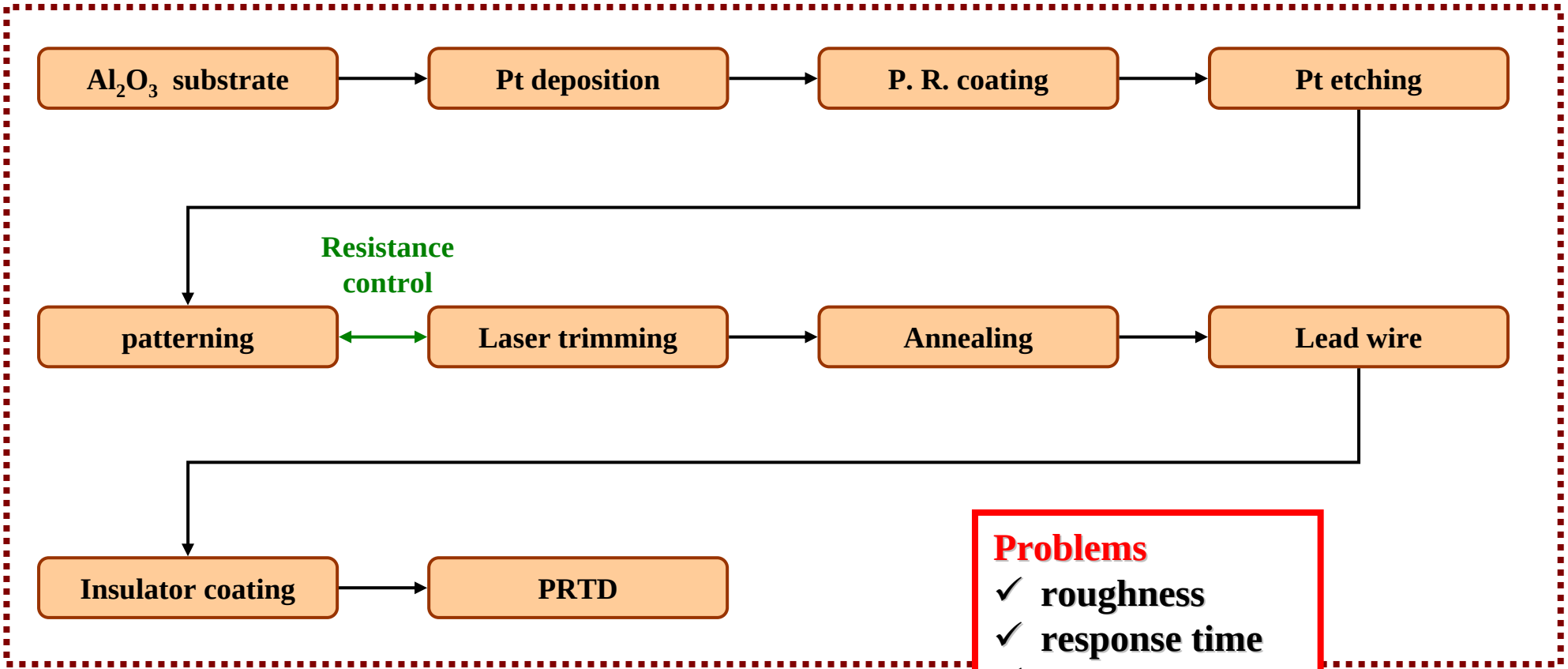
For realization of platinum resistance temperature detectors, effective film thickness is required (see red line)



Pt TCR values as a function of film thickness*

* ref. : R. D. Baxter, P. J. Freud, US Patent, 4375056 (1983)

Conventional Pt-RTD process (Commercial products)

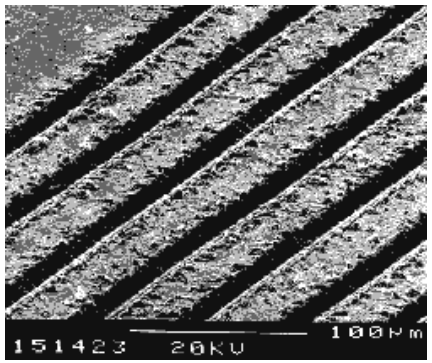


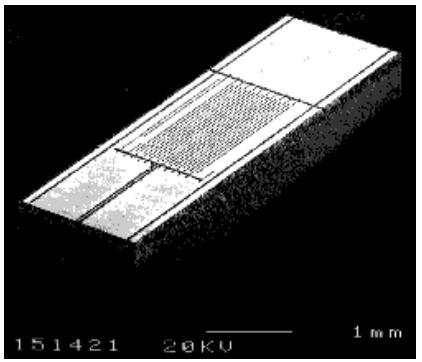
Problems

- ✓ roughness
- ✓ response time
- ✓ Pt etchability
- ✓ laser trimming
- ✓ cost

Conventional patterning process (commercial products)

Laser trimming

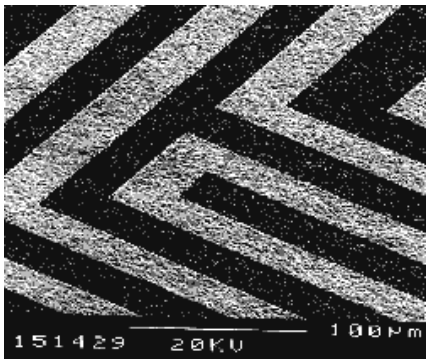


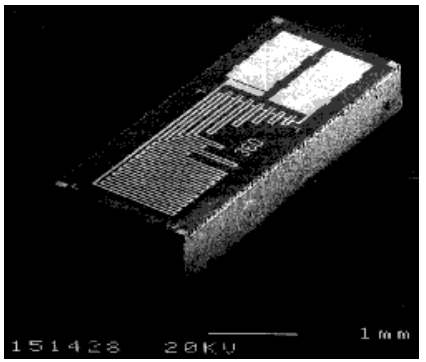


Disadvantages

- Degradation of Pt film
- Limitation of line width to the laser beam size
- Low yield

Photolithography





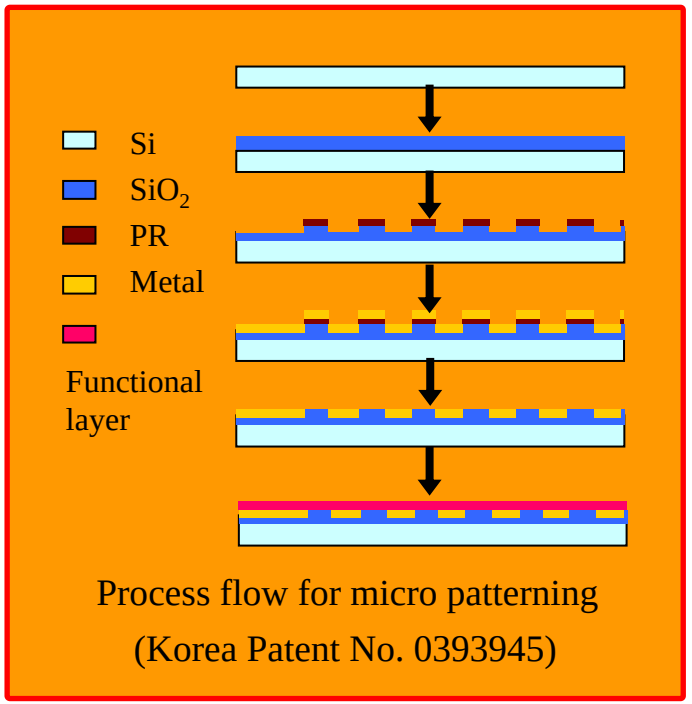
Disadvantages

- Trimming pattern is necessary
- Etchability of Pt is not good.

Embedded patterning

Feature of INOSTEK's Micro-patterning Technology

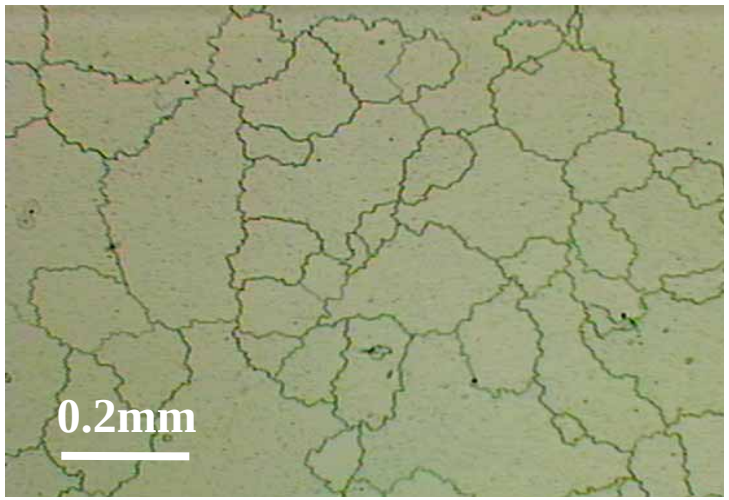
- Embedded pattern
- No needs for planization
- Compatibility with other processes
- High yield

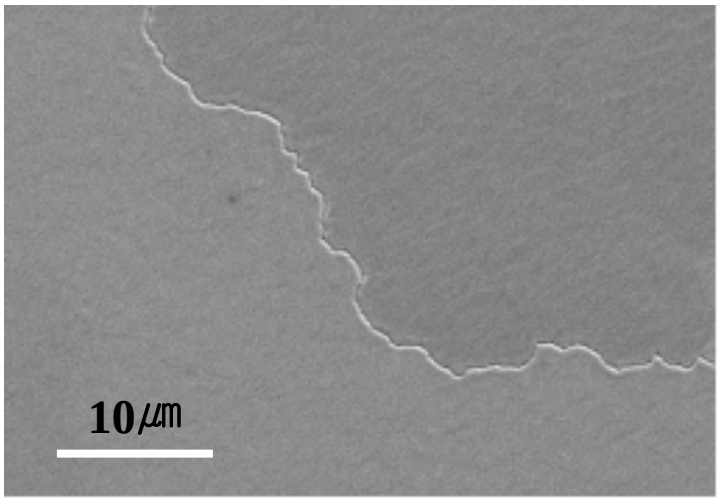


Process flow for micro patterning
(Korea Patent No. 0393945)

Giant grained Pt films

❖ Giant grained Pt films are used as sensing materials



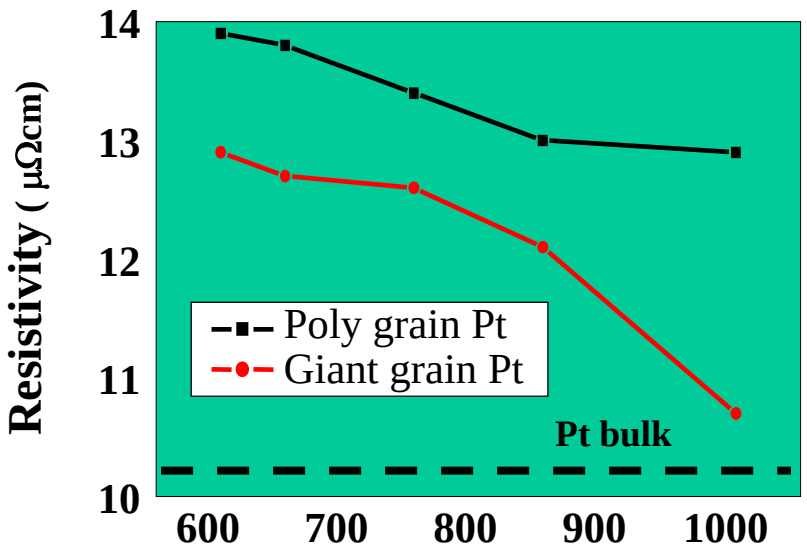


- Giant grained Pt film consisting of cm-ordered grains can be made by sputtering with $Ar+O_2$ gas mixture.
- The preferred orientation of giant grained Pt can be controlled.
- After annealing, deposited Pt film completely transforms to giant grain.
- The resistivity of giant grained Pt is lower than that of normal grained Pt.

Giant grained Pt films

The resistivity of giant grained Pt was lower than normal grained Pt.

Resistivity of giant grained Pt films



cf. Resistivity of bulk Pt : 10.6 μΩcm at 25℃

INOSTEK's Platinum RTD sensor

Using Si wafer substrates

Device Spec.	unit	World best spec.	R&D spec. in KOREA	INOSTEK spec.
TCR[1)]	1/℃	0.00385	0.0038	0.00385
Standard Resis.[2)]	Ω	100 ~ 10000	100	100 ~ 10000
Line width	㎛	10		10
Dimension[3)]	mm^2	1x1	5x5	2x2
Tolerances	℃	±(0.15 + 0.002*t)		± (0.15 + 0.002*t)

[1)] TCR: temperature coefficient of resistance

$\alpha = (R_{100} - R_0) / (100 * R_0)$ in /°C

R_{100} : resistance at 100℃ , R_0 : resistance at 0℃

[2)] Standard resistance: resistance at 0℃ (R_0)

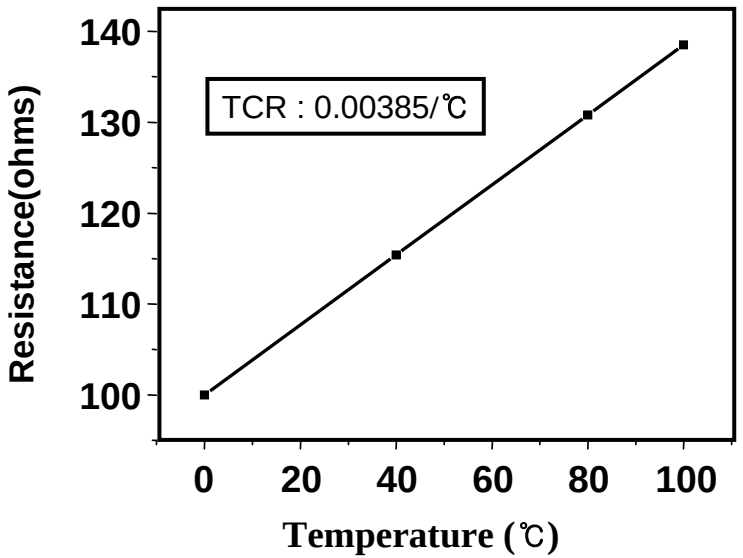
Sensitivity ($\Delta R/\Delta T$) depends on R_0

[3)] Dimension : response time, self-heating error

Characteristics of INOSTEK's Pt RTD sensor

TCR depends on
- ✓ purity
- ✓ thermal mismatch between substrate and platinum film
- ✓ annealing temperature

TCR measurement



TCR: temperature coefficient of resistance

$\alpha = (R_{100} - R_0) / (100 * R_0)$ in /°C

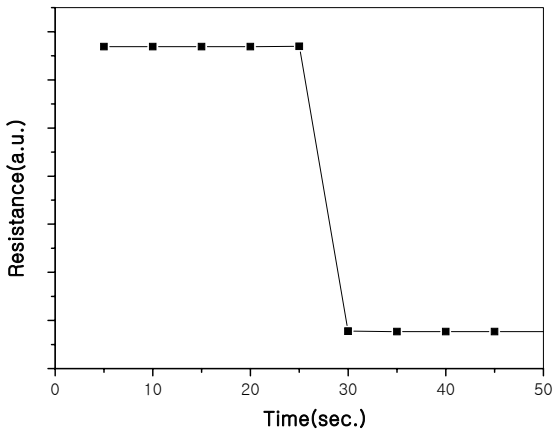
R_{100} : resistance at 100℃ , R_0 : resistance at 0℃

Characteristics of INOSTEK's Pt RTD sensor

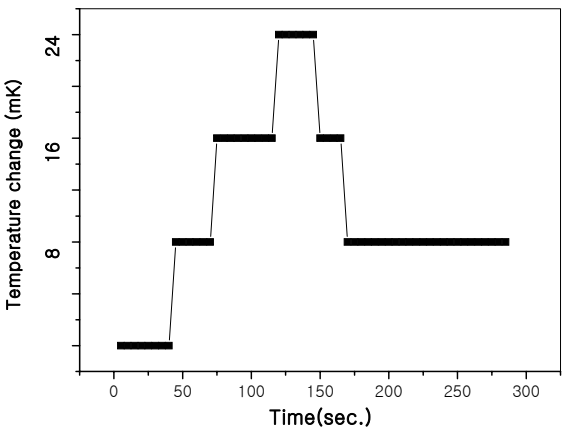
❖ ***Fast response*** due to the high thermal conductivity of Si wafer

6 times
- ✓Al_2O_3 : 25 W/mK
- ✓Si wafer : 148 W/mK

Measurement of time constant
(from 25℃ to ice point)



Self heating effects



Self heating caused by measuring current could be reduced by fast heat transfer.

Thus, Si wafer is more useful than alumina as a substrate.

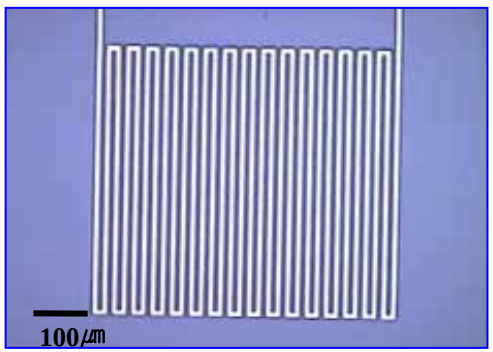
INOSTEK's Platinum RTD sensor and RTD wafer

- Based on silicon wafer
- Microstructure control of platinum (Single crystal Pt film)
- Unique patterning method

INOSTEK's Technology

6 inch platinum RTD wafer

provides



Platinum RTD

TCR : 0.00385 R_o : 100, 1000, 10000Ω

Advantages

- Fast response
- Enhanced electrical properties
- Small sensing area
- Unlimited measuring points
- High accuracy by high standard resistance