GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Choices of Materials for Metallisation

L. D. Embury

Metallisation Processes

- Thin Film.
- Thick Film.
- Metallo –Organic.
- Electro –Plated.
- Polymer

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Thin Film

- **Advantages:-**
- Wide variety of metals can be applied by same technique in same equipment.
- Can obtain dense complete films.

- **Disadvantages:-**
- High cost of initial equipment.
- High cost of masks for each job size.
- Slow deposition rate.
- Adhesion tends to be low.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Thick Film

- **Advantages:-**
- Deposition by a range of techniques.
- Low cost methods of application.
- Low cost of masking techniques.
- Deposition of metal in one rapid operation.
- Excellent adhesion.

- **Disadvantages:-**
- Further processes i.e. firing cycle required to obtain metallic film.
- Higher definition requires disproportional increase in costs.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Metallo -Organic

- **Advantages:-**
- Deposition as thick film.
- Ability to deposit metal in range between that of thin and thick film.
- Films can be laid that are 100% dense as thin film.
- Mixed metal films are true alloys.
- Very high definition possible.

- **Disadvantages:-**
- Higher cost on a weight basis than thick film.
- Gets more difficult to lay non stressed film as film thickness increases.

Electro –Plating
Electroless / Electrolytic

- Advantages:-
- Relatively simple technique.
- Low raw material costs.
- Can be easily applied to base metals.

- Disadvantages:-
- Multi –stage process printing and etching of masks sometimes required.
- Serious environmental problems associated with disposal of waste.

MetallisationObjective

- Mechanical Connection.
- Electrical Connection.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Mechanical Connection

- To join ceramic to metal.
- To provide conductive pathway on inert substrate.
- To provide magnetic or electrical shielding.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Mechanical Connection Properties of Metals

Metal Melting Point (°C)	Electrical Resistivity (10-6 Ω-m)	Thermal Expansion (10-6 °C-1)	Thermal Conductivity(W/m C)
Al. 660	2.42	23.1	237
Ag 960	1.6	19.7	418
Au. 1063	2.2	14.2	297
Cu. 1083	1.7	17.0	393
Ni 1445	6.16	13.4	91
Pd. 1552	10.8	11.0	71
Pt. 1774	10.6	9.0	71
Mo. 2625	5.2	5.0	146
W. 3415	5.5	4.5	201

Electrical Connection

- To provide the connection from the circuit to the electro ceramic or sensor device.
- May be internal or external to the component under consideration.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Component Varieties

- Capacitors.
- PZT Devices.
- Varistors.
- Tantalum Capacitors.
- Sensors.
- Microwave Components.
- Multilayered Devices.
- NTC Devices
- PTC Devices

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Capacitors

- Electrodes are required to give:-Good mechanical adhesion.
- Surfaces that are capable of being soldered.
- Conductivity of metal film without ion migration into the ceramic body.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

P.Z.T. Devices

- Electrodes are required to give:-Resistance to mechanical stress.
- Resistance to ion migration under high electrical stress.
  - Resistance to poling bath chemicals.
  - Surfaces that are capable of being soldered.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Varistors

- Electrodes are required to give:-Good mechanical adhesion.
- Capability of carrying high current.
- Surfaces that are capable of being soldered

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Tantalum Capacitors

- Electrode in two or three parts:-
- Barrier layer paste, usually carbon, generally applied by dipping.
- High conductivity paste, usually silver polymer combination; if encapsulated, solderable.
- If S.M.D
- compatible with conductive adhesive.
- Conductive adhesive for lead frame.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Sensors

- Sensors are of two basic types and the electrodes are required to have:-
- For active substrate i.e. oxygen sensor, good and stable electrical contact.
- For passive substrate, non reactivity to applied sensor material

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Microwave Components

- Electrodes are required to give:
- Good adhesion.
- High Definition.
- High Conductivity.
- High Density.
- Good Solderability.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Multilayered Devices

- Require:-
- Internal Electrode.
- External Electrode.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Internal Electrode

- Required to give electrical connection onto the electroceramic.
- To withstand the high firing conditions of the electroceramic.
- To match the thermal expansion characteristics of the electroceramic.
- Not to migrate into the ceramic material during firing.
- To form “chemical key” if possible with the electroceramic.

External Electrode

- Required to carry signal only, and form an adhesive key to the component.
- Secondly, be capable of connection to leads or the circuit directly (S.M.D.).

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

N.T.C. Devices

- Electrode requirements:-
- Good adhesion.
- Low electrode deterioration with time.
- Low ion migration.
- Metal type dependent upon the transition metal oxide that the N.T.C. component is made from.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

N.T.C. Electrodes

Type of NTC	Application	Operating range	Metal
Zero power thermal sensing	temperature measurement	0 to 250°C	Ag
Zero power thermal sensing	temperature measurement	0 to 350°C	Al
Zero power thermal sensing	temperature measurement	350°C plus	Ni / Pt / Pd etc.
Self heating sensing	Voltage regulation		Ag.
Indirectly heated sensing	Phase shifting	0 to 150°C	Ag.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

P.T.C. Devices

- Requirements:-
- Good adhesion.
- Low ohmic contact onto the electroceramic.
- Capable of surviving high electrical and thermal stress.
- Capable either of compliance for clamp bonding or be solderable.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

P.T.C. Devices

- Low Power :
- Sensors
- Static heaters.
- Constant temp. heaters.
- Current control.
- Voltage control.
- Heat dissipation control.

- High Power :
- Dynamic Circuit timers.
- Current timers.
- Motor starting.
- Choke timers.
- Fuel evaporation.
- Air heaters.

P.T.C. Devices

- Elements which can “poison” P.T.C. devices:-
- Alkali metal ions.
- Transition metals.
- Acceptor dopants.
- Anions.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

P.T.C. Devices Typical Electrode Systems

Electrode system	Electrode system Method of application	Typical usage	Typical Usage Ohmic Connection	Conductive pathway
Ni / P :Ag	Electro-less Ni & Electrolytic Ag	Degausser / Motor Start	Ni : P	Ag
Al /Cu	Thin Film	Choke Heater / Degausser	Al	Cu
Ga / In	Ultrasonic Solder	R & D	Ga	In
Ag / Zn :Ag	Thick Film	Current Control	Zn : Ag	Ag
Al	Thin Film /Thick Film	Degausser / Heaters	Al	Al

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Base Metal Electrode Systems

- Air Fireable Base Metal Electrodes:-
- Aluminium
- Nickel
- Fugitive (Metal Injection) processes.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

New Electrode Systems

- Current Techniques to Lay Base Metals:-
- Thin Film.
- Electroplating.
- New Electrodes by Air Fireable Base Metal Thick Film Inks:-
- Aluminium.
- Nickel.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Air Fireable Base MetalElectrodes

- Properties:-
- Resistance to ion migration.
- Conductivities in the same range as precious metal films.
- Shrinkage matchable to electroceramics.
- Major cost savings.
- Fireable in existing equipment.
- Possibility of solder contact.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

New Termination Inks General

- Polymer
- No high firing temperature.
- Can be soldered.
- Can be plated.
- Reduced number of processing steps.
- Reduced cost.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Summary

- Trends:-
- Away from thin film.
- Away from high cost precious metals.
- Increased usage of organo –metallic films.
- Increased usage of base metals as electrodes.
- Potential of polymer terminations.

GWENT GROUP
ADVANCED MATERIAL SYSTEMS

Les. Embury
Managing Director
The Gwent Group,
Monmouth House,
Mamhilad Park,
Pontypool NP4 0HZ.
United Kingdom.
sales@gwent.org
http://www.gwent.org
Tel: +44 (0)1495 750505
Fax: +44 (0) 1495 752121