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Design guidelines for capability approval of film hybrid microcircuits and microwave hybrid integrated circuits (MHICs)

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ABSTRACT

This specification provides design guidelines for thick- and thin-film hybrid microcircuits (including microwave hybrid integrated circuits) and is intended to serve as a reference document when a manufacturer's design rules and production processes are considered for the purpose of the capability approval programme defined in ESA PSS-01-605, ESA PSS-01-606 and ESA PSS-01-612.

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SECTION 1: SCOPE

This specification provides design guidelines for thick- and thin-film hybrid microcircuits (including microwave hybrid integrated circuits) and is intended to serve as a reference document when a manufacturer's design rules and production processes are considered for the purpose of the capability approval programme defined in ESA PSS-01-605, ESA PSS-01-606 and ESA PSS-01-612.

For the procurement of flight hybrids, the design rules of the approved PID shall apply.

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SECTION 2: APPLICABLE DOCUMENTS

The following documents are applicable to the extent specified herein:

ESA PSS-01-20	Quality assurance of ESA space systems
ESA PSS-01-60	Component selection, procurement and control for ESA space systems
ESA PSS-01-70	Material and process selection and quality control for ESA space systems
ESA PSS-01-201	Contamination and cleanliness control
ESA PSS-01-301	Derating requirements and application rules for electronic components
ESA PSS-01-605	The capability approval programme for hermetic thin-film hybrid microcircuits
ESA PSS-01-606	The capability approval programme for hermetic thick-film hybrid microcircuits
ESA PSS-01-607	Checklist for thick-film hybrid microcircuit manufacturers and line survey
ESA PSS-01-608	Generic specification for hybrid microcircuits
ESA PSS-01-611	Checklist for thin-film hybrid microcircuit manufacturers and line survey
ESA PSS-01-612	The capability approval programme for microwave hybrid integrated circuits
ESA PSS-01-701	Data for selection of space materials
ESA PSS-01-702	A thermal vacuum test for the screening of space materials
ESA PSS-01-708	The manual soldering of high reliability electrical connections
ESA PSS-01-716	The listing and approval procedure for materials and processes
ESA PSS-01-722	The control of limited life materials
MIL-STD-202	Test methods for electronic and electrical component parts
MIL-STD-883	Test methods and procedures for microelectronics
MIL-H-38534	Hybrid microcircuits, general specification for

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SECTION 3: RECOMMENDATIONS AND GUIDELINES

These recommendations and guidelines are intended for general reference and may change as a result of evolution of the technology. All designs for film hybrid microcircuits shall adhere to the requirements of ESA PSS-01-301 (Derating requirements and application rules for electronic components).

3.1 DESIGN RULES

3.1.1 General

(a) Maximum dimensions of substrate:
- 52 x 52 mm in the case of encapsulated hybrids and microwave circuits.
- 100 x 125 mm in the case of unencapsulated hybrids.

(b) Maximum number of conductor layers for thick-film hybrid microcircuit: 8
For the case of multi-layer circuits, a minimum of 2 dielectric layers should be printed between each conductor layer. Multi-layers are not permitted for thin-film hybrid microcircuits

(c) In general, only single-sided coating and chip component mounting will be considered. However, the reverse side of a substrate may be used for coated earth plane or simple 1-layer conductor lines with a width of 1 mm minimum.

(d) If possible, holes in substrates are to be avoided. However, if they are required, their diameter shall be 1 x substrate thickness minimum, or 0.7 mm maximum and exceed the lead wire diameter by at least 0.1 mm. Holes shall not be metallised on the inside nor filled with solder, epoxy or other material. Feed-through wires shall be neither short nor rigid; their length, flexibility and geometrical design shall be such that thermal expansion is possible. For microwave circuits holes up to 2.0 mm are permitted.

(e) Recommended minimum thickness of substrates:
'a' = 0.08 SQRT('b') or 0.4 mm, whichever is the larger.
('a' = thickness in mm; 'b' = longest side-length in mm)

(f) Maximum ratio between long and short sides of substrate shall be 4 : 1. Substrates shall normally be square or rectangular in shape. Other shapes, including substrates having internal angles greater than 180°C, may only be used with the prior approval of ESA.

(g) The following design guidelines (Sections 3.1.2 to 3.1.10) apply to thick-film circuits which are produced by screen printing and subsequent processing of paste materials and to thin-film circuits which are produced by photolithographic etching of premetallised substrates. Where techniques other than these are to be used, application shall be made to the European Space Agency in advance.

3.1.2 Conductor Lines

(a) These lines should preferably follow the main axes of the substrate or be at an angle of 45° to these axes. This preference is to be ignored if technical considerations require otherwise.
(b) Minimum line width should be 0.15 mm for thick-film and 0.02 mm for thin-film.
(c) Minimum distance between lines produced during a single operation is to be 0.15 mm for thick-film and 0.025 mm for thin-film.
(d) Minimum distance between lines printed during two different operations is to be 0.2 mm.
(e) Minimum distance between substrate edge and side of each line is to be 0.25 mm. This requirement does not apply to termination areas or lines wider than 0.25 mm.
(f) Maximum current or power load is to be defined during evaluation.
(g) Recommended rules in case of printing irregularities are:-
(i) Minimum line-width: 2/3 x design line-width;
(ii) Minimum distance between lines: 2/3 x design distance.
(h) Recommended minimum thickness of microwave conductor lines for minimum attenuation is:

0.01245/SQRT (f) mm

where f is the frequency in GHz.

3.1.3 Termination Areas

(a) Conductors and printed resistors are to overlap by at least 0.2 mm (applies to thick-film only).
(b) Conductor areas for resistor termination are to be at least 0.1 mm wider on either side of the resistor than the resistor itself (applies to thick-film only).

(c) Conductor areas for termination of passive chips$^{1)}$ are to extend beyond either side of chip metallisation for connection by at least 0.25 mm (0.05 mm for microwave circuits).

(d) Minimum size of areas for lead termination by soldering:
Round wires:
'b' = 3 x 'd', but 1.5 mm minimum;
'l' = 10 x 'd', but 3 mm minimum.

Flat strips of maximum 0.2 mm thickness:

'b' = 2 x 'w', but 1.5 mm minimum;
'l' = 4 x 'w', but 3 mm minimum.

Fork-type termination, clamped and soldered on both sides of substrate:

rules for flat strips are to be applicable.

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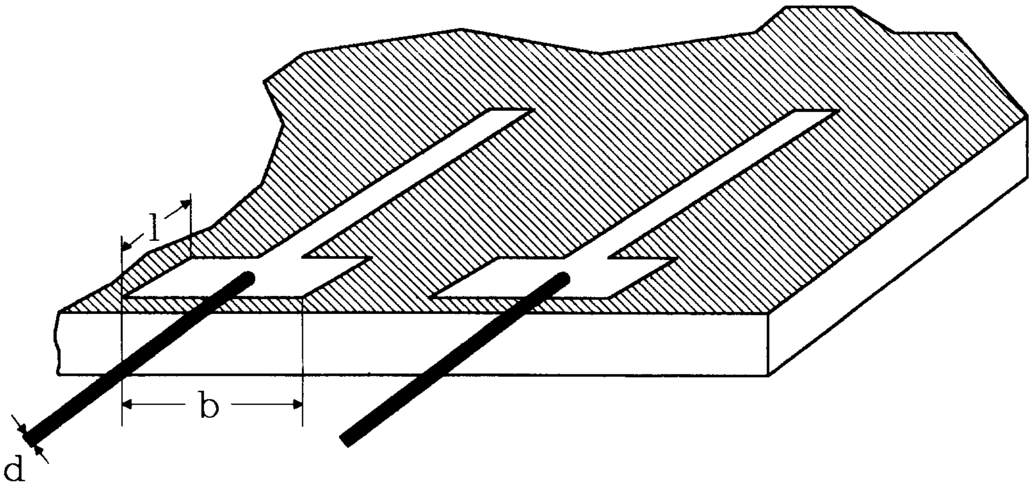
1) If passive chips are wire-bonded, the requirements specified in Paragraph 3.1.5 are applicable.

FIGURE 1 - TERMINATIONS



(e) For microwave circuits only, minimum size of areas for RF terminations by soldering is to be:

Round pins :-
'b' = 'd' + 0.2 mm but 0.8 mm minimum
'l' = 1.0 mm minimum

Flat strips :-
'b' = 'w' + 0.2 mm but 0.8 mm minimum
'l' = 1.0 mm minimum.
Terminating areas intended for soldering by Sn/Pb solder shall be overplated with a barrier layer. Dimensions of the barrier layer shall be 0.05 mm greater than the terminating area.

3.1.4 Resistors

(a) Overlap: see Paragraph 3.1.3(a).
(b) Thick film resistors are to be printed directly on to the substrate and not on to printed insulation layers. This does not apply to multi-layer circuits which are to be assessed separately.
(c) Circuits are to be protected by cover-glaze if they have to be dip-tinned or if resistors have to be subjected to abrasive trimming. Only those resistors that are deposited directly on the substrate may be trimmed. Thin film resistors may not be subjected to abrasive trimming.

(d) It is recommended that resistors follow straight lines.
For thick-film, meanders, zig-zag patterns, loops etc. are to be avoided as far as possible. Concentric (coaxial) resistorsystems are to be allowed if required for technical reasons, but proof must be given in that case that the resistor area close to the inner conductor termination is not overloaded.Meanders may be used for thin-film resistors. Where this is required trimming should, wherever possible, be performed on shorting bars rather than the body of the resistor track.

(e) Where resistors are not trimmed, the minimum width of the resistor shall be 0.5 mm for thick-film or 0.1 mm for thin-film.

(f) Where resistors are trimmed, the minimum width of the resistor shall be 0.7 mm for thick-film or 0.2 mm for thin-film.

(g) Maximum resistor width: 10 x length of resistor.

(h) Minimum distance between untrimmed resistors: 0.4 mm for thick-film or 0.1 mm for thin-film.

(i) Minimum distance between trimmed thick-film resistors at starting point of trimming paths: 0.7 mm for air-abrasive and 0.4 mm for laser trimming. Minimum distance between trimmed thin-film resistors 0.2 mm.

(j) Maximum resistor length: 15 x resistor width (applies to thick film only).

(k) Minimum resistor length: 0.7 mm for thick-film .

(l) For thin-film, minimum resistor length shall be 0.1 mm if the resistor is not to be trimmed and 0.2 mm if the resistor is to be trimmed.

(m) For thick-films, minimum resistivity of resistor paste shall be 1 Ω/mm/square. For thin-films, minimum resistivity of nichrome resistors shall be 50 Ω/mm/square, for tantalum nitride 20 Ω/mm/square, other materials upon application to ESA.

(n) For thick-films, maximum resistivity of resistor paste:
10 Ω/mm/square unless test requirements specify otherwise. For thin films, maximum resistivity of nichrome resistors shall be 250 Ω/square, for tantalum nitride 150 Ω/mm/square, other materials upon application to ESA.

(o) Recommended trimming rules: see Figure 2.

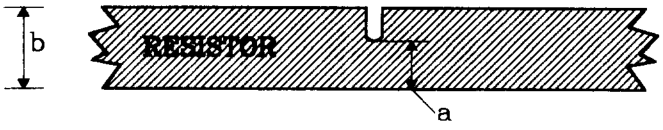
(p) Maximum current or power load: see Paragraph 3.1.2(g).

(q) The design shall permit visibility of the full length of each resistor, i.e. no resistor shall be hidden from sight by attached chip components.

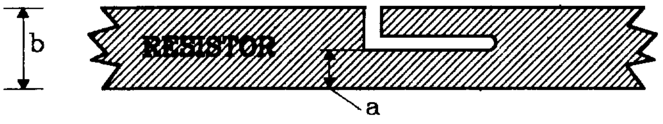
FIGURE 2 TRIMMING RULES

For thick-film:
a = 1/2 x 'b' minimum or 0.4 mm, whichever is the larger.

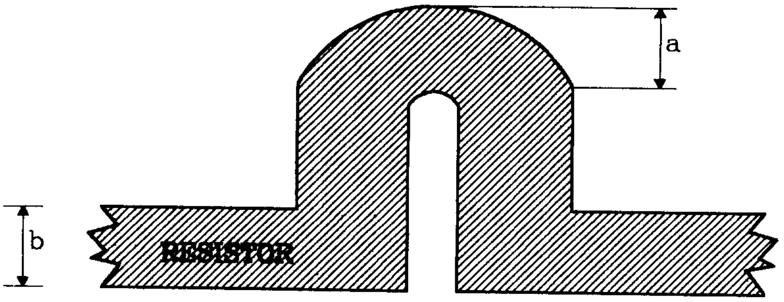
For thin-film:
a = 3/4 x 'b' minimum or 0.15 mm, whichever is the larger.



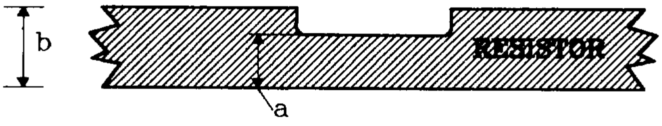
a = 1/2 x 'b' minimum or 0.4 mm, whichever is the larger.



a = 2/3 x 'b' minimum or 0.4 mm, whichever is the larger.



a = 1/2 x 'b' minimum or 0.4mm, whichever is the larger.

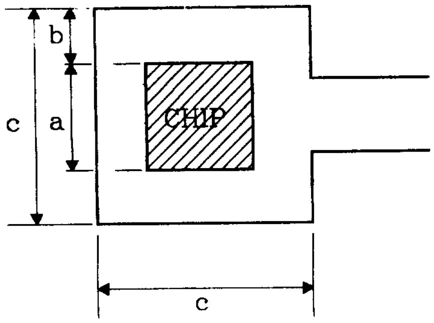


Other trimming rules may be considered provided that the maximum power dissipation is taken into account for the minimum resistor area after trimming.

3.1.5 Areas for Semiconductor Chips

(a) Minimum dimensions of islands for die-bonding:
'b' to be 0.2 mm minimum. For microwave circuits only, 'b' to be 0.05 mm minimum.

FIGURE 3 AREA FOR SEMICONDUCTOR CHIPS



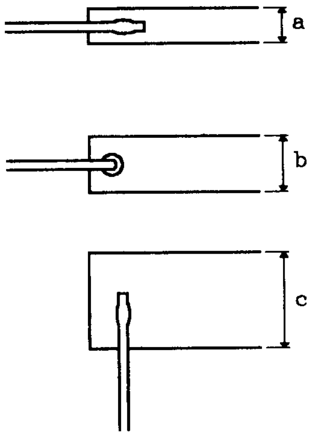
(b) Landing area for bonding wires of up to 175 µm
'a' = 4 x wire diameter,
'b' = 8 x wire diameter,
'c' = 8 x wire diameter.

These figures are for guidance only and do not apply to wires of over 175 µm

Line width is decided by the shape of the bonding foot.

For microwave circuits only, landing area for bond wires up to 75 µm diameter :
'a' = 3 x wire diameter,
'b' = 6 x wire diameter,
'c' = 6 x wire diameter, except for Lange couplers when 'c' is reduced to 3 wire diameter.

FIGURE 4 AREA FOR BONDING WIRES



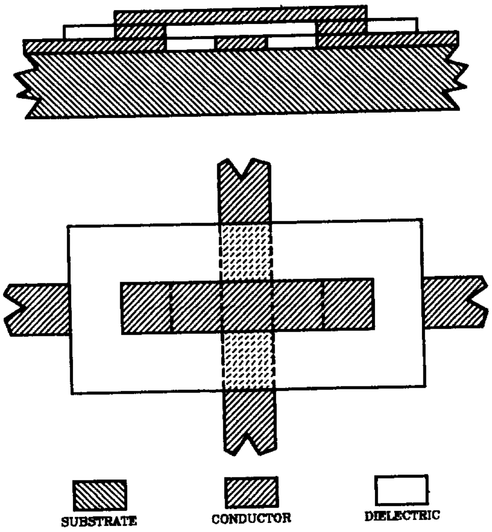
(c) Maximum distance between bonding points of same wire: 100 x wire diameter for gold wires and 120 x wire diameter for aluminium wires.

(d) Minimum height at which wire is bent down to reach substrate shall be 8 x wire diameter above chip surface.

3.1.6 Printed Cross-overs

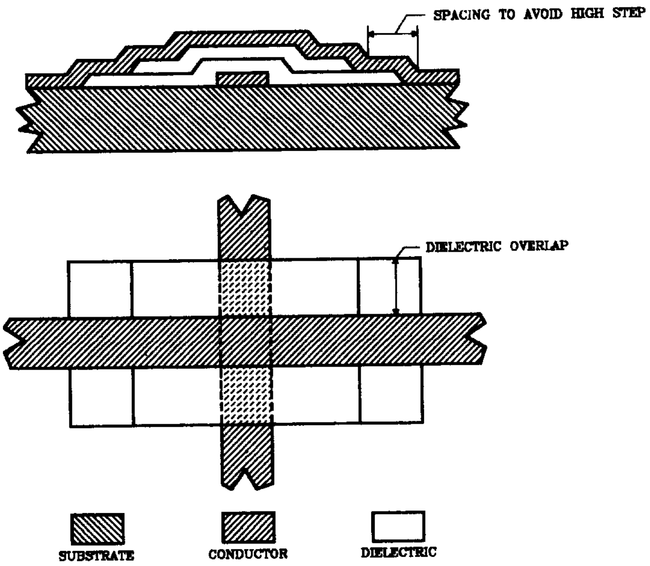
(a) For thick-film, two printed cross-over methods are recommended, viz.:
Method I : "Bridge" method with filled "vias" and
Method II: Simple overprinting.
Other methods must be demonstrated by microsections during evaluation.
For thin-film, deposited cross-overs are not permitted.

FIGURE 5 PRINTED CROSS-OVERS



Method 1
Bridge method with
filled via's

Two dielectric printings
Three conductor printings



Method 2
Simple overprinting
Two dielectric printings
Two conductor printings

(b) Method I is allowed in all cases. Method II is allowed only in the case of noncritical printing where linewidths and line distances are 0.15 mm or above for the overlapping line system.

(c) Whether Method I or Method II is adopted, two dielectric layers shall be printed. The existence of two independent layers in the critical crossing point will in itself decrease the risk of pin-hole shortcircuit, even if the layers are thin.

(d) Successive dielectric layers shall be printed and fired according to the thick-film manufacturer's specification.

(e) It is recommended that a layer of cover glaze shall be placed over the entire crossover dielectric as a protection from humidity and other contamination. The decision on whether to use a cover glaze or not shall be taken during approval testing of the production line. The decision shall depend on the type of dielectric paste used (especially with respect to hygroscopicity) and the required level of insulation resistance.

(f) Cross-overs shall not be made over resistors.

(g) Dielectric overlaps shall be 0.15 mm minimum.

3.1.7 Wire Cross-overs and Wire Connections

(a) Wires shall not cross over other wires.

(b) Wires shall not cross chip components.

(c) Wires shall not cross resistors.

(d) If a wire whose diameter is equal to, or less than, 50 µm, crosses a conductor line, the line shall be overprinted by an insulated layer covering the conductor lines so far that, in the worst case, the wire cannot touch the unprotected line.

(e) For Au wires, the maximum distance between bonding points shall be 100 x wire diameter or 5 mm, whichever is less. For Al wires, the maximum distance between bonding points shall be 120 x wire diameter or 6 mm, whichever is less.

(f) If outgoing lead terminations are attached by soldering, the landing areas shall be as specified in Paragraph 3.1.3(d); if they are attached by wirebonding, the landing areas shall be as specified in Paragraph 3.1.5(b).

(g) For microwave interdigitated structures (e.g. Lange couplers) wires crossing over conductors are permitted.

3.1.8 Crossings beneath Chip Capacitors

These are allowed provided the clearance between conductor and chip termination is 0.25 mm minimum and the conductor is covered by an overglaze or a dielectric. Where the clearance between the conductor and chip terminations is less than 0.5 mm two layers of overglaze or dielectric shall be used.

3.1.9 Encapsulated Component Mounting

In general, encapsulated components are mounted on a thick-film screen-printed substrate by means of soldering. Soldering requirements are prescribed in Section 6 of Specification ESA PSS-01-708.

3.1.10 Mounting Plates and Enclosures for Microwave Circuits

(a) All substrates shall be mounted on to metallic mounting plates or into metallic enclosures which are expansion matched to the substrate material. Allowed combinations of substrates and metals are specified in Section 3.2.5.14.
(b) Substrates shall be attached to mounting plates or enclosures using solder or conducting epoxy.
(c) RF connection to substrate through enclosure wall; the outer conductor shall be screwed or soldered into the wall; the centre conductor shall be either sliding pin, (soldered to the MHIC conductor line) or ribbon connection (soldered or welded to the conductor line).
(d) Enclosures are to be hermetically sealed if active semiconductor chips are incorporated.

3.1.11 Encapsulated Component Mounting for Microwave Circuits

In general, encapsulated components are to be mounted on substrates and mounting plates by soldering. If Sn/Pb solder is used to attach components to gold tracks a barrier layer must be used. Soldering requirements are prescribed in Section 6 of ESA PSS- 01-708.

3.1.12 Substrate Interconnection for Microwave Circuits

Electrical interconnection between substrates is to be by welded gold ribbon or soldered Sn/Pb plated copper ribbon. Soldered Sn/Pb plated copper ribbon should only be used in combination with suitable surfaces, materials and barrier layers.

3.2 MATERIALS

3.2.1 Suppliers' Certificates

All materials and components shall be delivered to the hybrid microcircuit manufacturer together with a certificate pertinent to whichever of the following items is relevant:
(a) Origin of material/component,
(b) Location of plant (in case supplier has several plants),
(c) Exact type designation of material/component,
(d) Technical description of material/component and guarantee,
(e) Date on which manufacture was completed,
(f) Batch number,
(g) Date of shipment,
(h) Shelf life (if applicable),
(i) Exact storage and temperature conditions (if applicable).

Items (h) and (i) apply to materials with a limited storage life,e.g. thick-film pastes, conductive epoxies, solder pastes etc. Each container (bottle, case etc.) and each certificate shall be marked immediately upon receipt to enable identification of delivery lot and corresponding certificate. All certificates shall be kept by the hybrid microcircuit manufacturer and, upon request, shown to the Agency's representative.

3.2.2 Utilisation and Storage Conditions

Materials with a limited life time shall be stored as specified by the supplier. They shall not be used after the final usage date specified in the supplier's certificate unless a validation test, to be agreed with ESA or the orderer, has produced satisfactory results.

3.2.3 Operational Temperatures

The temperature range applicable to operational conditions of long duration is specified for some of the materials listed in Paragraph 3.2.5. It shall be borne in mind that the highest temperature is the absolute maximum for extended operation and takes into account both ambient and local hot spot increases. It shall be also remembered that, in operation, a space component will be more severely affected by temperature owing to lack of air convection.

3.2.4 Selection of Materials

Paragraph 3.2.5 recommends general rules for the selection of materials for the hybrid microcircuits defined in this specification. It shall be noted, however, that only those materials and combinations of materials that have been processed as specified in this specification and have successfully passed all of the production line approval tests specified in ESA PSS-01- 605, 606 and 612 are allowed.

3.2.5 Materials and Components

3.2.5.1 Ceramic Substrates for Thick-Film

Substrates shall be as follows:

(a) Material : Alumina (Al_2O_3) and beryllium oxide (BeO). If BeO is used, the package shall be marked as specified in specification ESA PSS-01-608.

(b) Purity : 96 to 99.8%.

(c) Specified impurities : Maximum 4%.

(d) Unspecified impurities : Maximum 0.1%.

(e) Microsurface : Minimum 0.10 µm RA (Average roughness value) (4 µinch/CLA); : Maximum 0.75 µm RA (30 µinch CLA). Substrate roughness values apply only to sides to be printed. Maximum allowable value on reverse side shall be 2 µm RA (80 µinch/CLA).

(f) Flatness : Maximum 0.004 mm/mm (inch/inch).

(g) Thickness : See Paragraph 3.1.1.

(h) Macrosurface : Holes, elevations, fissures, etc. shall not be visible under magnification X10 and flat angle, collimated light. Elevations and total camber of substrates for power circuits shall be lessthan 50 µm on the side to be attachedto the package or heat-sink. This requirement is independent of the dimensions of the substrate.

Items (a) through (e) to be certified by supplier in accordance with Paragraph 3.2.1(d).

3.2.5.2. Uncoated Substrates for Thin-Film

Substrates shall be as follows:

(a) Material : Alumina (Al_2O_3), beryllium oxide (BeO), fused and single crystal quartz (silica), sapphire. Other materials may be used upon application to the European Space Agency. If BeO is used the package shall be marked as required by specification ESA PSS-01-608.

(b) Purity : To be specified by supplier (e.g. 99.5% or 99.6% alumina).

(c) Specified impurities : To be specified by the supplier.

(d) Unspecified impurities : Maximum value to be specified by supplier.
(e) Microsurface : See Table 1
(f) Flatness : See Table 1
(g) Thickness : See Paragraph 3.1.1
(h) Macrosurface : See Table 1
(i) Additional properties of thin-film substrates suitable for microwave applications are presented in Table 1A.

3.2.5.3 Coated Substrates for Thin Film

(a) Substrate material : This shall comply with the requirements of Paragraph 3.2.5.2.
(b) Coating : The following materials (other materials may be used upon application to the European Space Agency).
  (i) Conductors
    Copper/gold
  (ii) Barrier/adhesion layers
    Chromium
    Tungsten -10% titanium
    Nickel
  (iii) Resistors
    Tantalum nitride (Ta_2N)
    Nichrome (2 - 2.5% silicon)
(c) Coating thickness : ± 20% of specification for plated substrates
: ± 10% of specification for sputtered substrates

TABLE 1 REQUIREMENTS FOR THIN-FILM SUBSTRATES

Line Thickness	Microsurface	Flatness	Av. Grain size	Macrosurface
Conductors >0.125mm (0.005")	'A' face <0.1µm (4µinch)CLA max.	Substrates 0.625 mm (0.025") and below - <0.002mm/mm (inch/inch)	<1.5µm	'A' face. Burrs >25µm(0.001") high and >250 µm (0.010") diameter-none
		Substrates 1mm (0.040") and 1.25mm (0.050") - <0.004mm/ mm (inch/inch)		
Resistors >0.125mm (0.005")	'A' face <0.075µm (3µinch) CLA max.	Substrates 0.625mm (0.025") and below - <0.003mm/mm (inch/inch)	<1.2µm	'A' face. Burrs >25µm(0.001") high and <250 µm (0.010") diameter-none
		Substrates 1mm (0.040") and 1.25mm (0.050") - <0.004mm/ mm (inch/inch)		
Conductors 0.050 - 0.125mm (0.002" - 0.005")	'A' face <0.1 um (4µinch) CLA max.	Substrates 0.625mm (0.025") and below - <0.002mm/mm (inch/inch)	<1.5µm 'A' face	Burrs >25µm (0.001") high and >125µm (0.005") diameter - none
		Substrates 1mm (0.040") and 1.25mm (0.050") - <0.004mm/ mm (inch/inch)		
Resistors 0.050 - 0.125mm (0.002") - 0.005")	'A' face <0.075 um (3µinch) CLA max.	Substrates 0.625mm (0.025") and below - <0.002mm/mm (inch/inch)	<1.2µm	'A' face. Burrs >25µm (0.001") high and >125 µm (0.005") diameter - none
		Substrates 1mm (0.040") and 1.25mm (0.050") - <0.004mm/ mm (inch/inch)		
Conductors <0.05mm (0.002")	'A' face <0.05 um (2µinch) CLA max.	Substrates 1.25mm (0.050") 1 mm (0.004") and below - <0.0005 mm/mm (inch/inch)	<1.5µm	Polished

TABLE 1A REQUIREMENTS FOR THIN-FILM SUBSTRATES

ADDITIONAL PROPERTIES OF MICROWAVE MATERIAL

Material	Purity	Dielectric Constant at 10 GHz, 25°C	Loss Tangent at 10 GHz, 25°C	Thermal Coeff. of Expansion x10^{-6}/°C
Alumina	99.5% min.	9.9 ± 2%	0.0002	6.6-7.0
Z-Cut Quartz X & Y Z	- -	*4.5 *4.64	*0.00002 *0.00002	12/22** 16
Beryllium Oxide	99.5%	6.8	0.0001	7.5
Fused Silica	-	3.82	0.0001	0.35
Aluminium Nitride	-	*8.8	*0.001	4.6

* at 1 MHz
** parallel to/perpendicular to the c-axis

(d)	Coating adherence	: MIL STD 883C Method 2004, Test Condition D. 1.27 mm x 0.25 mm (0.05" x 0.010") copper ribbon solder attached from the substrate edge along at least 6.5 mm (0.25") of its length to a 2 mm (0.075") thin-film test stripe. Perpendicular pull, 22 newtons (5 lb) minimum, film failure.
(e)	Resistor material resistivity	: See Paragraph 3.1.4 (m) and (n)
(f)	Resistor material stability	: Tantalum nitride 0.5% (150°C for 1000 hours). Nichrome 0.2% (150°C stability for 1000 hours). Other materials upon application to ESA.
(g)	Resistor material TCR	: Tantalum nitride -125 ppm/°C ± 25 ppm. Nichrome 0ppm/°C ± 25 ppm. Other materials upon application to ESA.

3.2.5.4 Pastes

(a)	Conductor metals	: Au, AuPt, AuPd, AgPd, AgPdPt, MoMn.
(b)	Conductor alloy composition	:To be agreed with supplier.
(c)	Metal content	:Dependent upon application of conductor, percentage in fired state.
(d)	TCR resistor pastes	: To be specified by manufacturer of thick-film hybrid microcircuits.
(e)	Resistor pastes	:Types not sensitive to pulse load static discharge or static discharge shall be preferred.
(f)	Resistor pastes	:1 Ω to 10 Ω per mm^2 or according to approval test results.
(g)	Dielectric	: Amorphous glass shall not be used. for cross-overs and capacitors
(h)	Cover glaze	: A transparent type shall be used to allow visual inspection of printed pattern.
(i)	NTC and PTC pastes	: May be used provided paste has passed evaluation tests. Evaluation test plan shall be drawn up by circuit manufacturer and approved by ESA.Tests shall be performed by circuit manufacturer.

(j) VDR pastes : See (i).
(k) Ferrite pastes : See (i).
(l) Blending of pastes : Resistor pastes of same type and from same manufacturer may be blended. In all other cases, blending shall not be allowed.
(m) Storage : Pastes shall be stored according to supplier's temperature recommendations unless test results prove that other storing conditions are more appropriate.
(n) Use of different brands of paste : May be used on the same substrate provided their compatibility has been demonstrated during evaluation testing according to ESA PSS-01-606.

3.2.5.5 Metals for Thin Film Depositions

Pure metals and alloys shall be specified by the supplier.

3.2.5.6 Plating Solutions, Photoresists and Etchants for Thin Film

These shall be specified by the supplier.

3.2.5.7 Solder Alloys and Materials for Terminations and Interconnections

Table 2 shows the allowed solder alloys together with the relevant melting ranges. Other alloys may be used provided they are covered by evaluation testing.

Table 3 lists the allowed materials for terminations etc. together with the applicable plating specifications.

Table 3A lists the allowed materials for microwave mounting plates and enclosures together with the applicable plating specifications.

Table 4 lists the allowed combinations of solder alloys and metal surfaces for soldering in conjunction with the maximum temperatures permitted for extended operation of these combinations. Barrier layers on microwave circuits for Sn/Pb soldering shall be electroplated nickel of 5 µm minimum thickness. It shall be noted that, unless otherwise specified, Table 4 defines the absolute maximum temperatures. In practice, temperatures may be restricted by considerations such as maximum temperature of the semiconductor chip, adhesion stability of thick-film paste etc. These considerations shall be covered by the chip component specifications or the requirements applicable to approval and procurement tests.

The following items shall be certified:
- Composition of solder alloys,
- Composition of terminal or interconnection base metal,
- Composition of platings,
- Thickness of platings,
- Evidence of sound, homogeneous and properly adherent platings without interface layers of impurities or other anomalies (micro-sectioning shall be required).

Certificates of compositions shall state also the percentage of impurities in metals.

3.2.5.8 Solder Pastes

Solder pastes shall meet the following requirements:
(a) The solder alloys used for their production shall be identical to those specified in Paragraph 3.2.5.7;
(b) The solder paste metal alloy/flux system shall be composed such that during soldering, the solder alloy produces a perfectly smooth and brightly shining surface without the appearance of a "pearly structure". No traces of solder metal shall be left in the solder residues in the form of either a grey film or of large metal pearls.
(c) The blending of different brands of solder paste, even if the alloy composition is the same, is not permitted.
(d) Pastes shall be stored at a temperature below 5 °C or as specified by the supplier.
(e) The requirements specified in Paragraph 3.2.5.9 for fluxes are also applicable to flux systems in solder pastes Items (a) and (e) shall be certified by the solder paste supplier.

TABLE 2 SOLDERING OPERATIONS

No.	Solder Alloy (1)	Specification	Melting Range
1	63Sn-37Pb	PSS-01-708	183°C
2	60SN-40Pb	PSS-01-708	183 - 188°C
3	62Sn-36Pb-2Ag	PSS-01-708	175 - 189°C
4	80Au-20Sn	(3)	280°C
5	90Pb-10Sn	(2)	280 -300°C
6	88Au-12Ge	(3)	356 - 800°C
7	94Au-6Si	(3)	370 - 1000°C
8	98Au-2Si	(3)	370 - 1000°C
9	75In-25Pb	(3)	160 - 170°C
10	50In-50Pb	(3)	190 - 215°C
11	25In-75Pb	(3)	250 - 264°C
12	72Ag-28Cu	(3)	780°C
13	96Sn-4Ag	PSS-01-708	221°C

NOTES:

(1) Alloy compositions are given in percentage of weight.

(2) 0.2% maximum antimony; 0.1% maximum bismuth;
0.8% maximum copper; 0.08% maximum other impurities.

(3) 0.2% maximum impurities.

TABLE 3 MATERIALS FOR TERMINATIONS AND INTERCONNECTIONS

		Inner Plating Layer		Outer Plating Layer		
No.	Base Metal	Deposition Method	Thickness/ Material	Deposition Method	Thickness/ Material	Final Treatment
1	Copper, bare	None	-	None	-	None
2	Copper(1)	None	-	Hot	4-20µm 60Sn-40Pb	None
3	Copper(1)	None	-	Electro	4- 8µm 60Sn-40Pb	Reflowed
4	Copper(1)	Electro	2-6µm Ni	Electro	1- 2µm Soft Au	None
5	Kovar or similar	Note 5	Note 5	Electro	1- 2µm Soft Au	None
6	Kovar or similar	Electro	2-6µm Ni	Hot	4-20µm 60Sn-40Pb	None
7	Kovar or similar	Electro	2-6µm Ni	Electro	4- 8µm 60Sn-40Pb	Reflowed
8	Monel or similar	Electro	2-6µm Ni	Electro	1- 2µm Soft Au	None
9	Monel or similar	Electro	2-6µm Ni	Hot	4-20µm 60Sn-40Pb	None
10	Monel or similar	Electro	2-6µm Ni	Electro	4- 8µm 60SN-40Pb	Reflowed
11	Gold(2)	None	-	None	-	None

NOTES:

(1) Copper: 99.95%, oxygen-free, annealed.
(2) Gold : 99.99%, soft; only for internal connections in packages.
(3) 60Sn-40Pb: According to Specification ESA PSS-01-708.
(4) Alloy compositions are given in percentage of weight.
(5) Nickel inner plating layer shall be as follows:

- for flexible or semi-flexible leads (i.e. flat packs):
- deposition method: electroplated nickel,
- thickness: min. 1.27 µm; max. 3.81 µm,

- for rigid leads (i.e. plug-in packages):
- deposition method: electroplated or, preferably, electroless nickel,
- thickness: min. 1.27 µm; max. 3.81 µm.

- for covers:
- preferably electroless nickel.

TABLE 3A MATERIALS FOR MICROWAVE MOUNTING PLATES AND ENCLOSURES

	Inner Plating Layer		Outer Plating Layer		
Base Metal	Deposition Method	Thickness/ Material	Deposition Method	Thickness/ Material	Final Treatment
Copper (1)	Electro	2-6µm Ni	Electro	1- 2µm Soft Au	None
Kovar or similar	None	-	Electro	1- 2µm Soft Au	None
Tungsten Copper	Electro	3-5µm Ni	Electro	4- 6µm Soft Au	None
Molybdenum	Electro	4-6µm Ni	Electro	1- 2µm Soft Au	None
Titanium	None	-	Electro	1- 2µm Soft Au	None
Titanium	Electro	2-3µm Ni	Electro	8-10µm 60Sn-40Pb(2)	Reflowed
Aluminium	None	-	Electroless	2- 8µm Ni	None

NOTES:

(1) Copper: 99.95%, oxygen-free, annealed.
(2) 60Sn-40Pb: According to ESA Specification PSS-01-708.
(3) Alloy compositions are given in percentage of weight.
(4) Materials for mounting plates are copper, Kovar of similar, tungsten copper, molybdenum or titanium.
Materials for enclosures are Kovar or similar, titanium or aluminium.

TABLE 4 ALLOWED COMBINATIONS OF SOLDERS AND METAL SURFACES TOGETHER WITH MAXIMUM TEMPERATURE FOR EXTENDED SOLDER JOINT OPERATION.

SOLDERS

1 = 63Sn 37Pb
2 = 60Sn 40Pb
3 = 62Sn 36Pb 2Ag
4 = 80Au 20Sn
5 = 90Pb 10Sn
6 = 85Au 12Ge
7 = 94Au 6Si
8 = 98Au 2Si
9 = 75In 25Pb
10= 50In 50Pb
11= 25In 75Pb
12= 72Ag 28Cu
13= 96Sn 4Ag

	SURFACES	1	2	3	4	5	6	7	8	9	10	11	12	13
		(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)
1	Copper, bare	85	85	85	125	125	125	No	No	70	85	125	150	85
2	Copper, hot tin	85	85	85	No	125	No	No	No	70	85	125	No	85
3	Copper, tin electro	85	85	85	No	125	No	No	No	70	85	125	No	85
4	Copper, Ni-Au(3)	85	85	85	125	125	150	150	150	70	85	125	150	10
5	Kovar, Ni-Au(3, 4)	85	85	85	125	125	150	150	150	70	85	125	150	10
6	Kovar, hot tin	85	85	85	No	125	No	No	No	70	85	125	No	10
7	Kovar, tin electro	85	85	85	No	125	No	No	No	70	85	125	No	10
8	Monel, Ni-Au(3, 4)	85	85	85	125	125	150	150	150	70	85	125	150	10
9	Monel, hot tin	85	85	85	No	125	No	No	No	70	85	125	No	10
10	Monel, tin electro	85	85	85	No	125	No	No	No	70	85	125	No	10
11	Molybdenum, Ni	85	85	85	No	125	No	No	No	70	85	125	150	10
12	Thick film, Au-Pt	85	85	85	125	125	150	150	150	70	85	125	No	85
13	Thick film, Au-Pd	85	85	85	125	125	150	150	150	70	85	125	No	85
14	Thick film, Au	No	No	No	125	No	150	150	150	70	85	125	No	No
15	Thick film, Ag-Pd	No	No	85	125	125	No	No	No	No	No	No	No	10
16	Thin film, Au (on gold-backed semi-conductor chips and similar)	No	No	No	125	No	150	150	150	70	85	125	No	10
17	Thin film Au, Ni plated	85	85	85	No	125	No	No	No	70	85	125	150	85
18	Molymanganese, nickel-plated or Ni+Cu-plated	85	85	85	No	125	No	No	No	70	85	125	150	85
19	Molymanganese(3) Au on Ni-plated	85	85	85	125	125	150	150	150	70	85	125	No	10
20	W-Cu, Ni-Au(3, 4)	85	85	85	125	125	150	150	150	70	85	125	150	10
21	Ti, Ni-Sn/Pb	85	85	85	No	125	No	No	No	70	85	125	No	10

NOTES: See next page.

NOTES TO TABLE 4

(1) Number apply to solders and materials for termination and interconnections specified in Tables 4 and 5.

(2) "No" means that combination is not allowed.

(3) Before soldering according to ESA PSS-01-708, Paragraph 5.1.4.3, gold shall be removed and solder area pre-tinned. For gold-tin and indium-lead solders there is no need to remove the gold.

(4) Identical alloys may be procured from other suppliers.

(5) When solders 1, 2 and 3 are used in combination with AuPt and AuPd for the making of internal joints in hermetic packages and such joints are protected from mechanical stresses, a thick-film operating temperature of up to 125ºC is permitted.
In such cases, the manufacturer shall certify that the joints themselves are stress-free by means of, say, annealed leads and/or the use of special mounting procedures which ensure that the connection strips or leads are already firmly fixed without the exercise of any force before solder is applied.

3.2.5.9 Solder fluxes.

The following requirements are applicable:

(a) Only moderately activated and non-activated fluxes shall be used.
The strongly activated fluxes normally used for the soldering of iron, nickel, Kovar and similar materials are not permitted in combination with thick-film substrates. This requirement is not applicable to fluxes used for the tinning of individual wire lead materials, packages, seals etc.; see Paragraph 4.2 of ESA PSS- 01-708 in this respect.

(b) Flux systems shall be composed such that removal of flux residues can be performed easily and does not leave any traces of discoloured or white residues. The removal methods are limited to those specified in Paragraph 3.2.5.10.
The solder flux supplier shall:
   (i) certify the degree of activation in respect of corrosiveness
   (ii) certify that flux residues, including activation agents, are fully soluble in organic solvents or indicate whether water-based solvents or a combined process is preferred.

The manufacturer of the thick-film hybrid microcircuits shall not rely solely on the flux supplier's advice on the rinsing procedure. Table 5 specifies the cleaning agents permitted for the final rinsing step. No special limits are applicable to earlier rinsing steps, provided the agents used are nondestructive to chips and compatible with thick-film materials, chip surfaces, conductive epoxies etc.

3.2.5.10 Cleaning

3.2.5.10.1 Ultrasonic Cleaning

Ultrasonic cleaning of circuits with wire or beam lead bonds is not permitted.

This cleaning method may be permitted for earlier rinsing steps, but it shall be borne in mind that its inherent cavitation effect may destroy fine line printing and the metallisation of semiconductor chips. Adequate precautions shall therefore be taken to prevent any damage of this nature. Points to be taken into account are the following:

Ultrasonic cavitation level in liquid,
Position of items in bath,
Number of items stacked together in the bath,
Stacking method,
Duration,
Visual inspection (magnification X10) of metal surfaces, especially of chips, after cleaning.

3.2.5.10.2 Flux Removal

Any trace of solder flux shall be removed before start of final rinsing step.

This process shall include the removal of thin glossy and transparent layers of resin, brown or black discolorations burned into the ceramic and traces or layers of dull, white or grey remnants of flux activators or mineral impurities adhering to the substrate surface.

Special attention shall be paid to the substrate surface beneath multi-layer chip capacitors where impurities may be trapped. To facilitate flux removal, it is recommended that the cleaning operation be performed when the flux is still soft, i.e. immediately after soldering. To prevent "burning" or dark discoloration of the flux, the soldering process should be of short duration and at a temperature sufficiently low for a heat-resistant flux.

It is advisable to apply a multi-step rinsing procedure using a very strong solution of resin solvent (e.g. 50% xylene + 50% isopropanol) for the first steps. The interim steps should then be performed using polar liquids which dissolve mineral impurities and activator remnants (ultrasonic cleaning may be performed at this stage provided wire and beam lead bonding has not yet been performed). One of the liquids specified in Table 5 should be used for the final steps.

TABLE 5 ALLOWED CLEANING AGENTS FOR FINAL RINSING STEP.

No.	Cleaning Agent	Special Requirements
1	Water	Max. conductance: 1µmho. Filtered to max. 2µm particles
2 3 4 5	Methanol Ethanol Isopropanol Acetone	Max. content of impurities other than water: 0.1%. Filtered to max. 2µm particles. Max. conductance: 1µmho
6	Pure Freon, Arklone or similar agent of other brand	Only in vapour phase
7	Azeotrope blend of (6) with (2), (3), (4) or (5)	Only in vapour phase

3.2.5.10.3 Semiconductor Chips

Wet cleaning (with e.g. isopropylic alcohol) of circuits containing wire-bonds or beam leads, or other types of unencapsulated semiconductor components, is permitted if evaluated and referenced in the PID.

Wet cleaning for the rework of wire-bonded semiconductors is allowed, but shall be followed by detailed visual inspection (microscope magnification X50-100) to ensure that all wires are in correct position, i.e. sufficiently interspaced to prevent shortcircuiting.

If semiconductor chips come into contact with cleaning agents, there shall be strict control to prevent the etching of aluminium metallisations (microscope magnification X50-100).

3.2.5.10.4 Acid-containing Cleaning Agents

Cleaning agents with a Ph value below 6 are not allowed.

3.2.5.11 Conductive and Nonconductive Epoxies and Other Adhesives

The following section deals with the selection of epoxies. Other organic adhesives may be used upon prior application to ESA but each Subsection (3.2.5.11.1 to 3.2.5.11.3) below must be addressed to the satisfaction of ESA.

3.2.5.11.1 Quality Assurance Procedure for Epoxies

(a) Type Selection
Selection of epoxy according to general rules specified in Subsection 3.2.5.11.3.

(b) Line Approval Tests
Epoxy is tested as part of the test structures subjected to the general line approval programme specified in ESA PSS-01-605, ESA PSS-01-606 or ESA PSS-01-612.

(c) Supplementary Tests
Submission of epoxy to the following tests which are supplementary to the line approval programme defined in ESA PSS-01-605, 01-606 or 01-612 :
- Outgassing,
- Infrared spectrum,
- Vacuum stability,
- Hardness and adhesion.

For test procedures, see Subsection 3.2.5.11.2.

(d) Incoming Inspection
Upon delivery, each lot of epoxy is to be subjected to infra-red spectrum test and hardness and adhesion test according to Subsection 3.2.5.11.2. Test results shall be identical to those obtained from the supplementary tests mentioned under (c) above.

(e) Usage of Epoxy
Epoxy shall be used according to the general rules defined in Subsection 3.2.5.11.3 and in accordance with ESA PSS-01-722.

3.2.5.11.2 Test Methods

(a) Outgassing
The purpose of this test is to assure that during the long period of thermal load, there is no outgassing of vapours which may contaminate chip surfaces, the interior of hermetically sealed packages, adjacent areas etc. Test methods and requirements shall be as defined in ESA PSS-01-702, "A Screening Test employing a Thermal Vacuum for the Selection of Materials to be used in Space".

(b) Infrared Spectrum
This test is aimed at determination of the chemical composition of the epoxy and to assure that the manufacturer does not deviate from this composition without changing the type designation and notifying the user. Moreover, this test may disclose any changes in composition as a result of mishandling or incorrect treatment during processing.
Using the KBr-plate method, the applicable spectrum shall be from 400 to 4000 cm^{-1}. Recommended solvents are butanol for hardeners and acetone for resins; a mixture of these two solvents may be used for one component epoxies. Precautions shall be taken to prevent the spectrum being affected by any filler material contained in the epoxy (centrifugation etc.).
When one component epoxies are used, a common spectrum shall be applicable to the unhardened category.
When two component epoxies are used, a separate spectrum shall be applied for unmixed and unhardened resins and hardeners. The spectra relevant to approved epoxies shall form part of the PID and be used for reference purposes in the identification of subsequently ordered batches.

(c) Vacuum Stability

In certain cases, it will be necessary to expose the mixed, but unhardened, epoxy to treatment under vacuum for removal of air bubbles introduced during the mixing operation.

In other cases, it may be necessary to apply an epoxy under vacuum to prevent air pockets in the adherent interface.

It shall be noted that exposure to vacuum may cause the evaporation of hardeners, or constituents thereof, which may result in incorrect reaction of the epoxy mixture.

Manufacturers shall therefore always ascertain the non-sensitivity of an unhardened epoxy to vacuum conditions by performance of the following test:

- Samples of the unmixed resin and hardener shall be placed in beakers and weighed;
- Mixtures shall be exposed to a vacuum of 0.5 Torr for 5 minutes at +25 °C and then weighed again;
- Weight loss shall not exceed 1%.

(d) Hardness and Adhesion

The purpose of this test is to ascertain the epoxy's ability to meet the specified hardening, consistency and adherence requirements. The test shall be performed as follows:

- Mixing of epoxy and hardener to within 2% of the specified ratio;
- Application of a dot of approx. 10 mm to a thoroughly cleaned and dried ceramic substrate of the type to be used for the space project;
- Hardening at the specified temperature and for the specified period;
- When cooled off, assessment of hardening and adhesion by scraping of, and cutting into, the dot by means of a scalpel. The dot of epoxy shall be of a hard, non-rubbery consistency and its removal from the substrate by cutting or flaking shall not be possible.

3.2.5.11.3 General Requirements and Recommendations for Epoxies

(a) Conductive Epoxies
The following requirements/recommendations are applicable:

- (i) One-component systems are recommended.
- (ii) Those types are recommended whose suitability for space or military projects has been proven and documented.
- (iii) Pure silver systems are permitted when:
  - the d.c. voltage gradient is less than 2V/mm between the conductive epoxy and any other conductor,

    or
  - the conductive epoxy is kept entirely within the area of the printed thick-film conductor on the substrate or chip component.
- (iv) In any other case, only pure gold systems shall be used.
- (v) Systems containing metals other than the above are not permitted.
- (vi) Storage temperature shall be between 0 and 5°C or as specified by the epoxy supplier.
- (vii) Conductive epoxies are permitted on the following surface types:
  - Thick film conductor Au, AuPd, AuPt, AgPd, AgPdPt,
  - Electro-plating : Au, Ag, Soft 99.9%,
  - Bulk metal : Au, Ag, Pt, 99%,
  - Thin film : Au, Pt.
- (viii) Maximum operating temperature of epoxy-containing circuit shall be +125°C.

(b) Non-conductive Epoxies
The following requirements/recommendations are applicable to non-conductive epoxies:

- (i) One-component systems are recommended.
- (ii) Those types are recommended whose suitability for space and military products has been proven and documented.
- (iii) Storage temperature shall be between 0 and 5 °C or as specified by the epoxy supplier.
- (iv) Maximum operating temperature of epoxy-containing circuit shall be +125°C.

3.2.5.12 Bonding Wires

Table 6 shows properties of bonding wires and ribbons. Where any bond wire or ribbon does not meet all of the requirements of Table 6, application should be made to ESA, in advance, giving full details of the deviation.

TABLE 6 BONDING WIRES AND RIBBONS

COMPOSITION	IMPURITIES MAX IN PPM EACH	TOTAL	DIAMETER OR DIMENSIONS (µm)	ANNEALING	ELONG-ATION (%)	BREAK MIN. (gm)
99.99% Au(2)	Ag 45	100	15	Hard	0.8 - 2	5
99.99% Au(2)	Cu 45	100	18	Hard	0.8 - 2	5
99.99%	Rest 20	100	25	Stress relieved	1 - 3	5
99.99% Au(2)	Rest 20	100	38	Ditto	3 - 8	10
99.99% Au(2)	Rest 20	100	50	Annealed	8 - 16	20
99.99% Au(2)	Rest 20	100	50	Ditto	1 - 3	30
99% Al 1% Mg,(3)	100	350	25	Stress relieved	1 - 3	10
99% Al 1% Mg,(3)	100	350	38	Ditto	1 - 3	20
99% Al 1% Mg,(3)	100	350	50	Annealed	3 - 8	30
99.999% Al	10	10	100	Ditto	8 - 16	100
99.999% Al	10	10	150		8 - 16	150
99.999% Al	10	10	175		8 - 16	175
99.999% Al	10	10	300		8 - 16	300
99%Al 1% Si	100	340	25	Hard	0.5 - 1	12
99%Al 1% Si	100	340	25	Ult. bond	-	12
99%Al 1% Si	100	340	25	Annealed	1 - 3	3
99%Al 1% Si	100	340	38	Hard	0.5 - 1.5	25
99%Al 1% Si	100	340	38	Ult. bond	-	25
99%Al 1% Si	100	340	100	Annealed	1.5 - 5	6

NOTES:

(1) Larger diameters should preferably not be used, but may be permitted if required for technical reasons.
(2) Purity greater than 99.995% not permitted.
(3) ± 0.2%
(4) Spool diameter shall be at least 500 x wire diameter.
(5) Each of the 7 requirements specified in this table shall be certified by the supplier.

3.2.5.13 Package and Mounting Plate Structures

See Section 3.2.5.14 for microwave circuit requirements.

Devices supplied according to this specification may be either hermetically sealed or open, unsealed, structures. Non-sealed structures shall be used only for circuits of great robustness and small complexity, i.e. simple resistor-conductor circuits with line width and spacings of more than 0.2 mm and without wire crossovers or unencapsulated chip components.

The following configurations apply to hermetically sealed packages. The same materials and processes are applicable to mounting plate structures and attachment of substrates to these. No desiccants shall be used in hermetically sealed packages.

Materials and Process Applicable to Packages. The basic material of metallic packages, lids and mounting plates may be either Kovar (or an identical alloy from a different supplier) or molybdenum.

FIGURE 6 PACKAGE CONFIGURATION A1

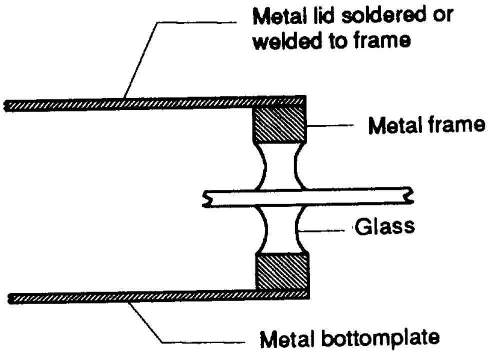
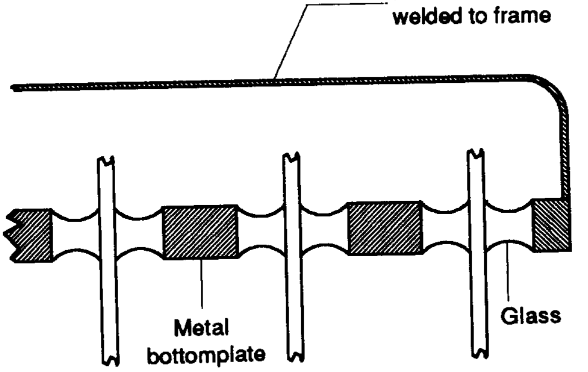
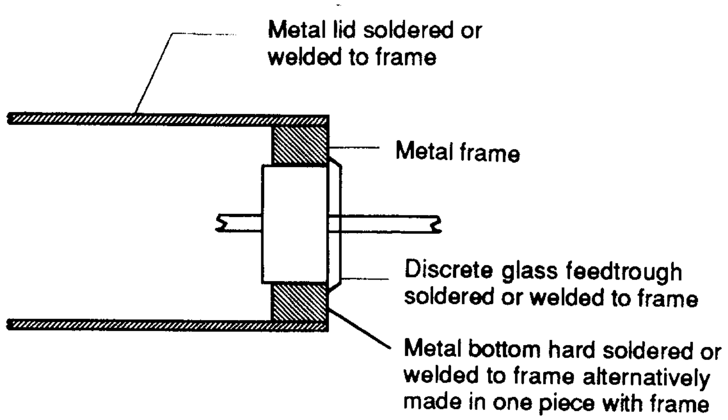


FIGURE 7 PACKAGE CONFIGURATION A2



Package Configuration A3 includes all other fully metallic packages built according to the same principle of A1 and A2 or the combination thereof. These types are characterised by having discrete glass feedthroughs soldered into the package frame or bottom.

FIGURE 8 PACKAGE CONFIGURATION A3



Feedthrough Pins may be made of Kovar (or an identical alloy from a different supplier). For discrete feedthroughs, Kovar, Monel, iron, nickel, iron-nickel or iron-nickel-cobalt alloys, either singly or connected with a copper core in cladding systems, may also be used. Restrictions on the use of ferromagnetic metals for pins, if magnetic properties have to be considered, shall be defined in the detail specification.

Platings for metallised packages and feed-through pins shall be in accordance with Table 3.

Ceramic Package Parts such as bottom plates, lids and side-frames shall be made of 96% Al_2O_3.

Metallisation of Ceramic Parts intended for metal solder seals or electrical feedthroughs shall be thick-film conductor layers or nickel-plated Molymanganese with or without additional copper (2 - 8µm), tin-lead or gold plating. For layer thicknesses, see under "Platings" above.

Glass-soldering of ceramic parts shall be performed directly on to ceramic surfaces without metallisation layers.

Metal solder alloys for Package-sealing shall be those specified in Tables 2, 3 and 4 and Section 3.2.5.7. They shall meet the requirements for surface platings, metallisation and base metals and not exceed the limits specified for maximum operating temperature.

Metal Package Assembly: if a package is not manufactured as a single homogeneous unit, the side-frame and bottom shall be assembled by welding or hard-soldering.

Substrate Attachment may be performed by means of either a conductive or a nonconductive epoxy or soldering. The use of epoxy for attachment to tin-lead surfaces is not permitted.

Thermal Sequence. Solder alloys and processes for attachment by epoxy shall be selected such that joints, materials etc. made during previous process steps are not affected by the temperature conditions applicable to the next step.

3.2.5.14 Enclosures and Mounting Plate Structures for Microwave Circuits

Devices supplied according to this specification may be either hermetically sealed or open, unsealed structures. Non-sealed structures shall be used only for circuits of great robustness and small complexity, i.e. simple circuits without unencapsulated active chip components. No dessicants shall be used in hermetically sealed packages.

Materials and Process Applicable to Enclosures and Mounting Plates. The basic material of metallic enclosures and lids may be Kovar (or an identical alloy from a different supplier), titanium or aluminium. The materials for mounting plates may be copper, Kovar (or similar), tungsten copper, molybdenum or titanium.

Feedthrough Pins may be made of Kovar (or an identical alloy from a different supplier). For discrete feedthroughs, Kovar, Monel, iron, nickel, iron-nickel or iron-nickel-cobalt alloys, either singly or connected with a copper core in cladding systems, may also be used. Restrictions on the use of ferromagnetic metals for pins, if magnetic properties have to be considered, shall be defined in the detail specification.

Platings for metallised enclosures, mounting plates and feedthrough pins shall be in accordance with Tables 3 and 3A.

Ceramic Package Parts such as bottom plates, lids and side-frames shall be made of 96% Al_2O_3.

Metallisation of Ceramic Parts intended for metal solder seals or electrical feed-throughs shall be thick-film conductor layers or nickel-plated Molymanganese with or without additional copper (2 - 8 µm), tin-lead or gold plating. For layer thicknesses, see under "Platings" above.

TABLE 7 ALLOWED COMBINATIONS OF MOUNTING PLATES AND SUBSTRATES

MOUNTING PLATE MATERIAL

1 = Copper
2 = Kovar or similar
3 = Tungsten copper
4 = Molybdenum
5 = Titanium

Substrate Material	1	2	3	4	5
Alumina	No	Yes	Yes	Yes	Yes
Z-cut Quartz	Yes	No	No	No	Yes
Beryllium Oxide	No	Yes	Yes	Yes	Yes
Fused Silica	No	Yes	Yes	Yes	No
Aluminium Nitride	No	Yes	Yes	Yes	No

NOTES:

The permitted solder alloys, metal solder pastes, fluxes and surface combinations for soldering, in conjunction with the maximum temperatures permitted for extended operation of these combinations are given in Sections 3.2.5.3, 3.2.5.4 and 3.2.5.5.

The requirements for conducting epoxies are given in Section 3.2.5.7.

Glass-soldering of ceramic parts shall be performed directly on to ceramic surfaces without metallisation layers.

Metal solder alloys for Package and Enclosure sealing shall be those specified in Tables 2, 3, 3A and 4 and Section 3.2.5.7. They shall meet the requirements for surface platings, metallisation and base metals and not exceed the limits specified for maximum operating temperature.

Metal Enclosure Assembly. If an enclosure is not manufactured as a single homogeneous unit, the side-frame and bottom shall be assembled by welding or hard-soldering.

Substrate Attachment may be performed by means of either a conductive epoxy or soldering. The use of epoxy for attachment to tin-lead surfaces is not permitted. Allowed combinations of mounting plate material and substrate are given in Table 6

Thermal Sequence. Solder alloys and processes for attachment by epoxy shall be selected such that joints, materials etc. made during previous process steps are not affected by the temperature conditions applicable to the next step.

Attachment of Mounting Plates into Enclosures. To achieve good grounding at microwave frequencies, mounting plates shall be attached into their enclosures by one of the following:
- mechanical clamping by screws
- soldering

For attachment by screwing, if the mounting plate material and enclosure material have significantly dissimilar thermal expansion, some means of stress relief shall be provided. The need for stress relief and the method used shall be agreed with ESA.

RF Grounding of Substrates. To provide an RF ground on the top surface of an MHIC substrate the following methods are allowed:
- Ribbon bonded or soldered to mounting plate. See Figures 9 (a) and (b).
- Ribbon wrap-around. Figure 9(c).
- Disc in hole and ribbon bond. Figure 9(d).

The choice of technique will be determined by several factors, such as frequency of operation, space available and circuit topology.

FIGURE 9 RF GROUNDING OF SUBSTRATES

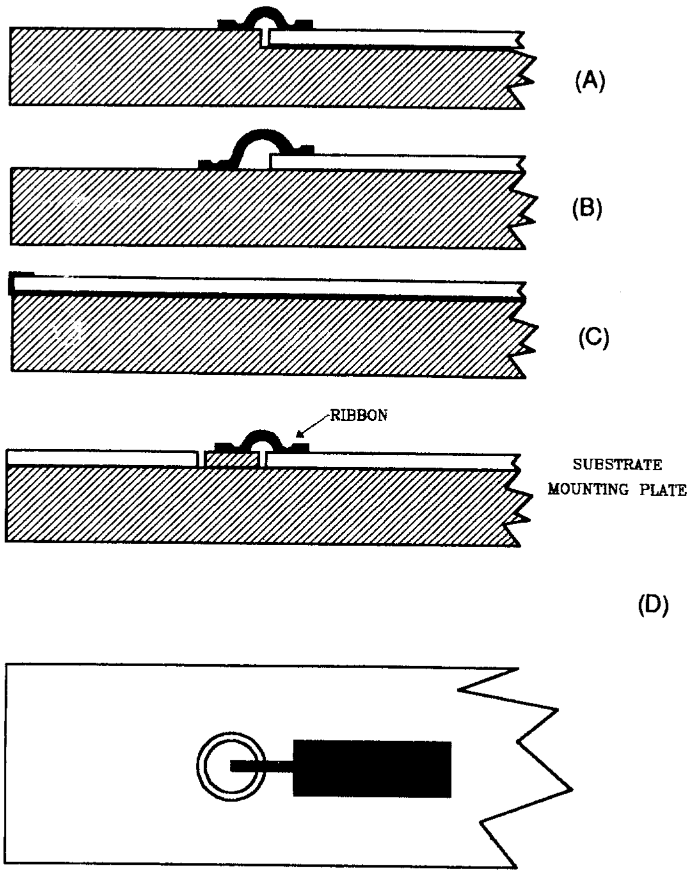
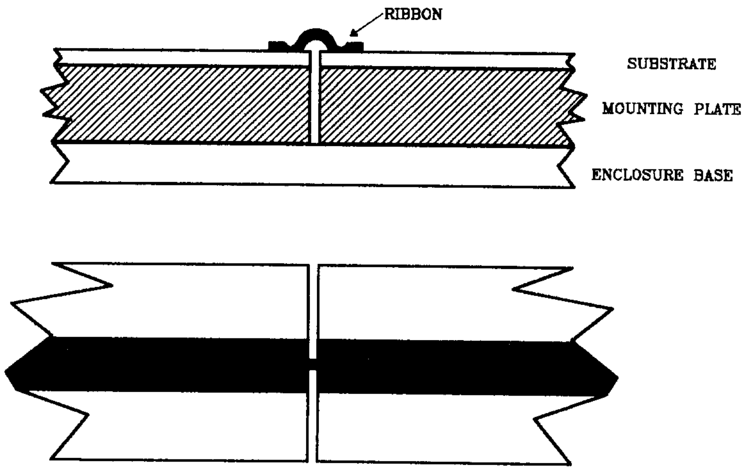


FIGURE 10 SUBSTRATE INTERCONNECTION



Interconnection of Substrates. Substrates attached to mounting plates and assembled into enclosures and substrates attached directly to the enclosure base shall be interconnected either by gold ribbons welded between the conductor lines or by Sn/Pb plated copper tape soldered between the lines, see Figure 10.

FIGURE 11 POST ASSEMBLY TUNING

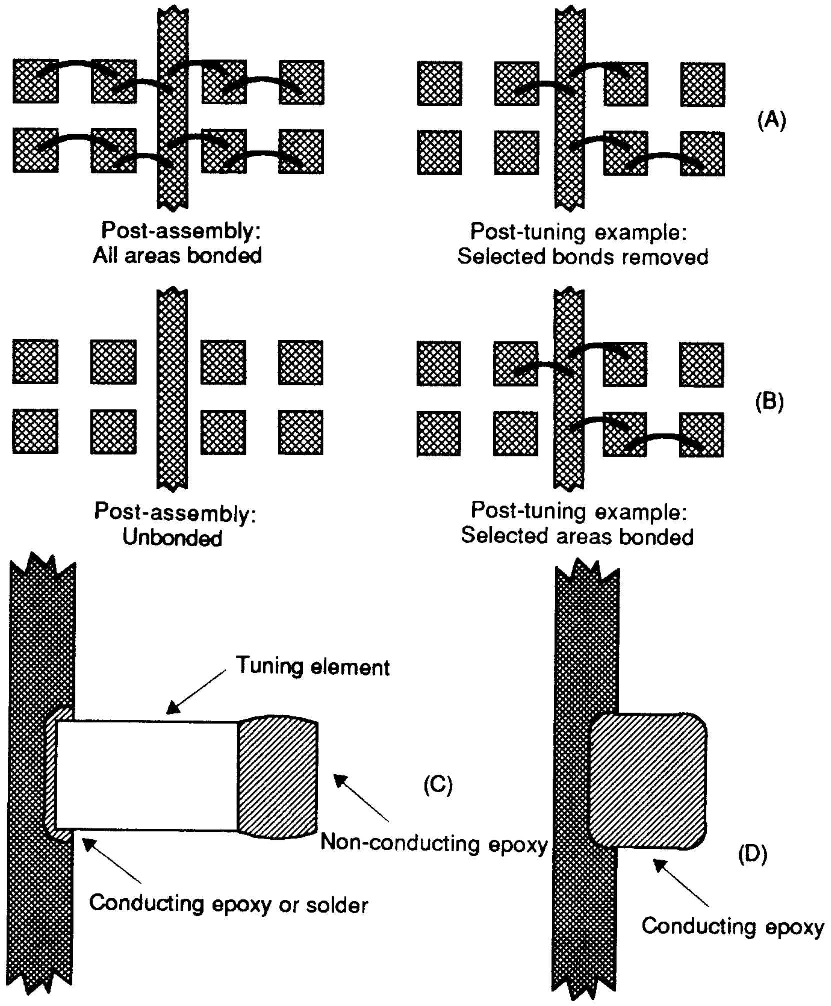
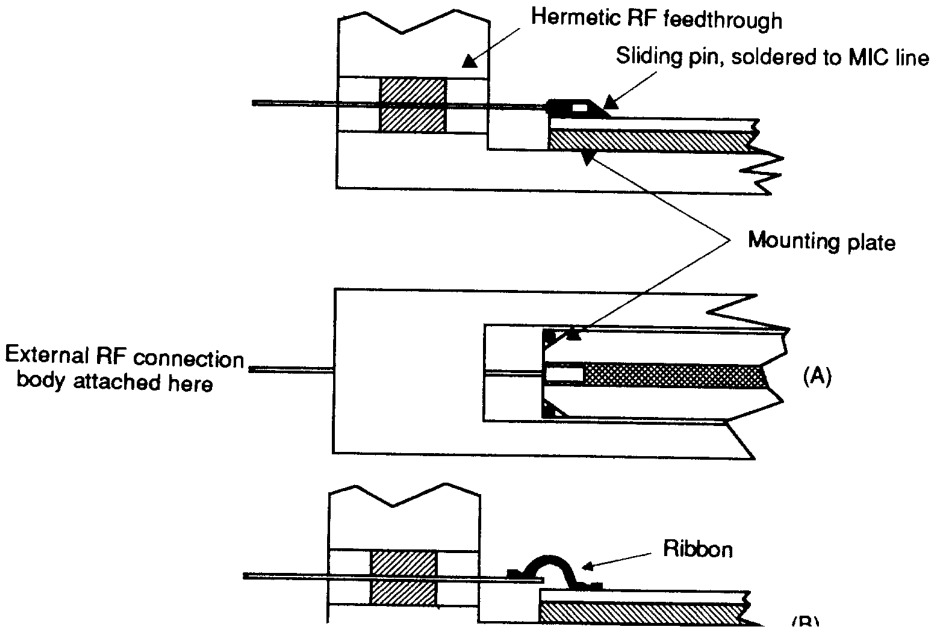


FIGURE 12 RF CONNECTION TO SUBSTRATE



Post-assembly Tuning If tuning of MHICs is needed to achieve specified microwave performance, then circuit adjustment by the following methods is allowed,

- Disconnection of pre-bonded areas or connection of unbonded areas by means of bond wires on to gold lines or Sn/Pb plated copper ribbons on to lines with barrier layers. See Figures 11(a) and (b). Any rebonding shall be on to areas free from the remains or imprints of bonds previously removed during the tuning process.
- Attachment of gold-plated, metal tuning elements by conducting and non-conducting epoxy or Sn/Pb plated copper elements by Sn/Pb solder on to regions with an appropriate surface or barrier layer and non-conducting epoxy. See Figure 11(c).
- Localised increases to conductor dimensions using conducting epoxy. See Figure 11(d).

Microwave Absorbers shall be selected for the appropriate operating frequency range and the degree of microwave attenuation required. Suitable absorber materials are listed in ESA PSS-01-701.
Attachment of the absorber to the enclosure or MHIC shall be by means of an approved adhesive - see ESA PSS-01-701.

Dielectric Resonators. Attachment of dielectric resonators to the MHIC shall be by means of an approved adhesive - see ESA PSS-01-701.

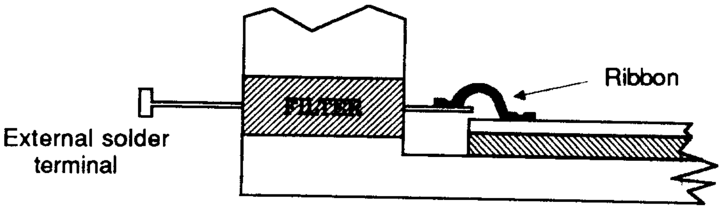
Packaged Transistors (Small Signal and Power). The ground connection of microwave small signal transistor packges shall be soldered to the mounting plate or enclosure base. See ESA PSS-01-708.
The ground connection of microwave power packages shall be soldered or mechanically screwed (as appropriate for each package style) to the mounting plate or enclosure base.
All other leads for both small signal and power transistors shall be soldered to lands with barrier layers on the substrate.

RF Connection to MHICs and RF Connector Requirements. RF connection through the enclosure wall shall be by hermetic RF coaxial connector. The centre conductor shall be supported in a hermetic glass/metal sealed bead soldered or brazed into the enclosure wall. The outer shall be screwed or brazed into the enclosure.
RF connection to the substrate shall be by either sliding pin on the centre conductor soldered to the MHIC conductor line or ribbon connection soldered or welded between the centre conductor and the MHIC conductor line. See Figures 12(a) and (b).

An important consideration at microwave frequencies is the continuity and integrity of the RF signal and ground plane connections. Precautions must be taken, therefore, when designing MHIC enclosures and assemblies that good RF connection is maintained from the external RF connector to the substrate. A typical MHIC enclosure assembly is shown in Figure 12(a) indicating the main design features.
Ground plane continuity is maintained by firmly screwing the RF connector outer body and the substrate mounting plate to the enclosure. Signal continuity is maintained by sprung solder pin connection from the connector to a hermetic glass/metal sealed bead and by a sprung sliding pin contact soldered to the MHIC conductor line.

DC Connection to MHICs and Connector Requirements. DC connection through the enclosure wall shall be by hermetic filtered feedthroughs soldered or brazed into the box with external solder terminal. Internal connection to the MHIC shall be by ribbon connection either soldered or welded between the connector and the MHIC DC conductor line. See Figure I3.
Selection or design of an appropriate DC feedthrough shall take into account the system RFI/EMI requirements external to the enclosure, the microwave frequency range and the power levels.

FIGURE 13 DC CONNECTION TO SUBSTRATE



RF Aspects of Enclosure Design. MHIC, being an "open", semi-infinite transmission medium is influenced by the proximity of surrounding metal objects. Enclosure design for MHIC must, therefore, take into acount the effects it may have on MHIC performance:

- To prevent waveguide mode propagation within the enclosure, the maximum dimension should be designed to be below the cut-off wavelength of the first waveguide mode at the highest frequency of operation, i.e. less than half the free-space wavelength at the highest operating frequency.
- Compartments or isolating walls should be included in large enclosures to ensure that each MHIC assembly is contained within a "below cut-off" section.
- If for layout reasons, (a) and (b) are not feasible, then microwave absorber material should be included within the enclosure to reduce waveguide propagation effects.
- For MHICs containing unencapsulated active chips, a hermetically-sealed enclosure shall be used, back-filled with dry nitrogen.
- The internal surface of the enclosure shall be sufficiently flat to ensure ground plane integrity between the mounting plate and the enclosure.
- Where the enclosure material and mounting plate material have significantly different coefficients of thermal expansion (e.g. aluminium and Kovar), some method of accommodating the differential thermal expansion shall be incorporated, e.g. one end of mounting plate screwed down tightly, the other allowed to expand freely by screws with spring washers.

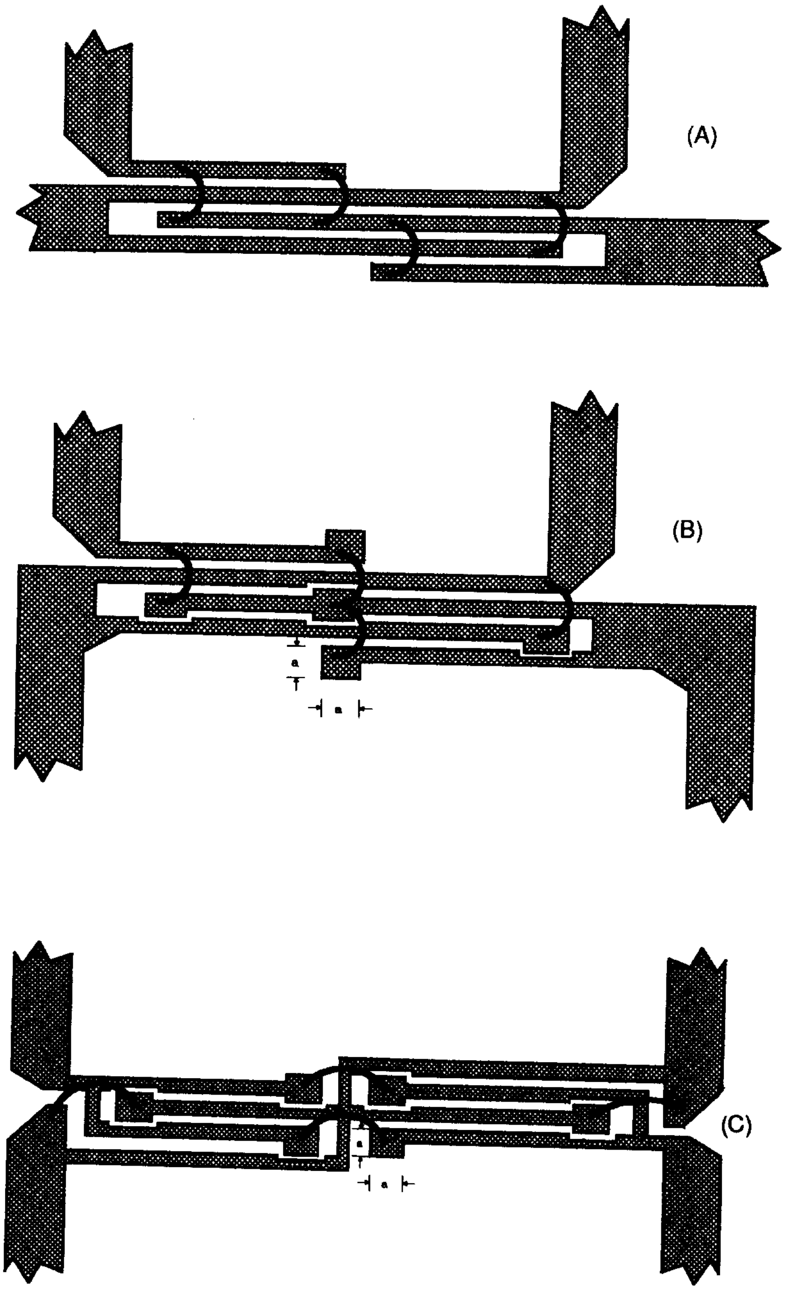
Interdigitated Couplers. The interdigitated coupler is a component frequently used in MHIC designs. Its advantages are that it provides wideband coupling with small physical size whilst maintaining relatively large line separation compared with the more conventonial two line MHIC couplers. An example of one form of the coupler for 3dB quadrature coupling is shown in Figure. 14(a). Transversely interposed fingers are interconnected using short bond wires to provide the required coupling between input and output ports.

To facilitate bonding to the narrow coupler fingers whilst at the same time minimising perturbation to the coupler's microwave performance, landing areas of bonding wires shall be provided as shown in Figures 14(b) and (c).

Minimum dimensions of the landing area:

a = 3 x wire diameter

FIGURE 14 INTERDIGITATED COUPLERS



ANNEX A: DEFINITIONS

CHIP COMPONENT

A component in its ultimate state of miniaturisation.

COMPONENT

A device which performs an electronic, electrical or electromechanical function and consists of one or more elements joined together which, normally, cannot be disassembled without destruction. The terms component and part are interchangeable. Typical examples of components are: transistors, integrated circuits, hybrids, capacitors etc.

DESTRUCTIVE PHYSICAL ANALYSIS (DPA)

A series of inspections, tests and analyses of a sample component, to verify that the materials, design and workmanship used for its construction as well as the construction itself, meet the requirements of the applicable specification and are suitable for the intended application.

DEVIATION

A written authorisation to accept a specific item which, during production or after inspection, has been found to deviate from the applicable requirements, but is nevertheless considered to be suitable for "use-as- is" or after "rework" by an approved method.

ENCLOSURE

A metal container with a lid into which one or more MHIC's are assembled either directly or after attachment to a mounting plate. Electrical connection to the MHIC is via RF and DC connectors through the enclosure walls.

FILM NETWORK

Layers of conductive, resistive, dielectric and/or passivating materials deposited on to an insulating substrate for the purpose of performing electronic circuit functions.

HYBRID MICROCIRCUIT

A component performing an electronic circuit function which consists of a thick-or thin-film network on a substrate which supports active and/or passive chip components connected to it.

LIMITED-LIFE MATERIAL

A material which can be processed and stored for only a limited period of time before deterioration of its specified properties.

MICROWAVE
Frequencies above 1 GHz

MOUNTING PLATE
A metallic plate or carrier providing both mechanical support and an RF ground plane for the MHIC substrate.

NONCONFORMANCE
An apparent or proven condition of any item or document that does not conform to the specified requirements and may lead to incorrect operation or interpretation during its envisaged usage. The term "nonconformance" is also used for failure, discrepancy, defect, anomaly, malfunction and deficiency.

PROCESS IDENTIFICATION DOCUMENT (PID)
A set of frozen documents defining the technology, processes and inspection procedures applicable to the manufacture of the components or items on order.

PRODUCTION LOT
A production lot consisting of a quantity of a specific device type manufactured on the same production line by the same processing techniques and according to the same component/part design using the same raw materials during one uninterrupted production run.

SELECTED SUB-LOT
A selected sub-lot is that part of a production lot which is manufactured in excess of the actual quantity of components required.

SYMBOLS AND ABBREVIATIONS
The symbols and abbreviations defined in MIL-S- 19500, MIL-M-38510, MIL-STD-883, Specifications ESA PSS-01-60, ESA PSS-01-606, this specification and the applicable detail specifications shall be applicable.

THICK-FILM
A network on to which the film is deposited by screen printing methods. The thickness of the fixed film is usually in the range of 10 to 25 micrometres.

THIN-FILM

A network on to which the film is deposited by one or more of the following processes: electro-depositing, plating, evaporation, sputtering, anodisation or polymerisation. The thickness of the film may be in the range of 50 to 12000 Angström·

TRACEABILITY

The ability to derive from recorded identification data the history, application, use and location of an item.