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SCT Barrel Module FDR Document

Cu/Polyimide barrel hybrids

abstract

This document outlines the hybrids used in the barrel modules

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Distribution List

SCT

History of Changes

Rev. No.	Date	Pages	Description of changes
A	07/05/01	All	First version

1 Introduction

A hybrid based on copper layers and organic insulator material has been developed for the application to the ATLAS SCT silicon microstrip modules. The technology has been widely used in the industry as a flexible circuit. The basic technology used to use “through-hole”s to connect the traces between layers. As the name “though-hole” indicates, the vertical connection between the layers was made with drilled holes penetrating all the layers. This penetration limited the freedom in laying traces and trace sizes at the “though-hole”s because of the minimum size of the drills. With the advent of micro-via formation, the technology is refined and developed to be “build-up” technology, since a layer can be overlaid over an underneath layer, layer-by-layer, by connecting the two layers with a small diameter of “via”s. The “build-up” flexible circuit is the key technology in industry to make the product small and light [1]. Benefiting from the latest technology, the ATLAS SCT has developed and chosen its hybrids made of the “build-up” Cu/Polyimide flexible circuit [2]. Another benefit of the flexible circuit is to make an one-piece construction of hybrid and cable combination. This eliminates vulnerable connections between the hybrids and cables.

Electrical function is one face of the hybrid. The other is the thermal and mechanical functions. Since the ASICs dissipate a power of 6 W in a module, a good thermal conduction is required in order to draining the heat out to the cooling element. A good mechanical strength is also required. The design of the barrel module is to make the hybrid bridging over the sensors so that the hybrid does not contact the surface of the sensors, other than the wire-bondings between the hybrid and the sensors. The hybrid bridge must be strong enough to make the supersonic wedge bonding of aluminium wire possible. The material of the bridge is required to be low in radiation length.

2 Electrical schematics

The electrical schematics of the hybrid is shown in the Figure 1 and Figure 2, “Circuit Diagram of Barrel Cu/Polyimide Hybrid for ABCD3T chips”. One module requires 12 ASICs; 6 ASICs per side. Two thermistors are equipped to monitor the temperature of hybrid; one per side. The digital and analog ground connection is made on the hybrid, aside of every ASICs.

The components of a hybrid is listed in Table 1.

The pin assignment in the connector at the end of pigtail is listed in Table 2.

Electrical properties of the hybrid is listed in Table 3.

3 Dimensions of the hybrid assembly

Dimensions of the hybrids are shown in Figure 3. The main hybrid sections are made of the area of 74.6 mm (L) x 21.3 mm (W). Two such sections are connected with a 8.4 mm long interconnect, and one end is connected to the pigtail cable of 35.4 mm long. These cable sections are the extension of the layers of the hybrid sections so that the hybrids and cables are made in one-piece, saving additional interconnections between the hybrid and cables. The Cu/Polyimide flexible circuit is reinforced with a substrate for the thermal, mechanical and electrical performance. The substrate has a cut-out in the bottom side in order to bridge over the silicon microstrip sensors.

The thickness of the hybrid from the bottom of the steps is 1.1 mm, including the adhesive layers between the flexible circuit and the bridges. The highest components in the hybrids are the SMD ceramics capacitors, C51~C58 and C71~C75 of the size of 3.2 mm (L) x 1.6 mm (W) x 1.25 mm (H), which height from the bottom is 2.6 mm, including a space between the components and the hybrid. The height of the wire-bonds on the ASICs is about 2.0 mm from the bottom with the ASIC thickness of 0.5 mm and an adhesive layer of 0.1 mm.

4 Specification of components

4.1 Cu/Polyimide flexible circuit

4.1.1 Layer structure

The layer structure of the flexible circuit is shown in Figure 4. The structure is a four Cu layer construction. Two Cu layers are made from a centre core of the double-sided Cu/polyimide sheet and two layers from two single-sided Cu/polyimide sheets glued on the core from top and bottom. The Cu layers of the centre core sheet extend the full length of the circuit from the pigtail connector to the far-end of hybrid. In the cable section the top and the bottom Cu layers are removed to be flexible and the remaining polyimide sheet to be a cover layer. The hybrid section has an extra layer of Cu resulting from the through-hole and via plating and the cover layers for insulation and protection. The Cu/Polyimide sheet is made with “adhesive-less” technology.

Through-holes and via’s are used for inter-connecting the layers: though-holes for the connections between the top (L1) and the bottom (L4) layers; via’s between the top two layers where buses and branches are running. The via’s are formed with a laser.

The layouts of layers are shown in Figure 5. The labels L1 to L4 show the layers from the top to the bottom. The functions of the layers are

- L1 bonding pads, branch traces to the pads from the longitudinal bus lines in the layer L2, and ground and shield planes
- L2 bus lines, and power supply planes in the cable section
- L3 analog and digital ground planes all-through the circuit
- L4 power supply planes, and windows for the ground contact to the bridges

4.1.2 Minimum line and gap widths

There are number of bonding pads in the back-end of the ABCD3T chips. The minimum pitch of the pads are 180 μm. The line/gap of the mating pads on the hybrid are, thus, to be 90 μm/90 μm. The width of the line where the wire bonding is made is better to be wider for ease of bonding. The industry has recommended the minimum gap of 80 μm in the large scale mass production, in order to ensure straight and clean-cut edges and non-existence of metal residues in the gaps. In the etching, the gap width becomes wider. Thus, the tolerance is specified for the minimum line/gap widths to be 100 +0/-20 μm for the line and 80 -0/+20 μm for the gap.

4.1.3 Thermal pillars

There are "thermal through-holes" in the "Front part, i.e., analog circuitry" area of each ASIC, which are vertically connecting the backside of the chips to the surface of the carbon-carbon bridge thermally. There are 17 such through-holes per chip. The diameter of each through-hole is 300 μm, plated with Cu, and filled with electrically conductive adhesive [ref. the section 5.4] when the flexible circuits are glued on the bridges. The effective thermal conductivity of the "pillar" is estimated to be about 40 W/m/K.

4.2 Carbon-carbon bridge

The bridges reinforcing the Cu/Polyimide flexible circuit is required to have a good thermal conductivity, high young's modulus, and low radiation length. It is shown to improve the electrical performance of the hybrid, specially the stability of the electronics near the zero threshold, by having an electrically conductive bridges and connecting the ground of the hybrid to the bridges.

The hybrids made with a carbon material called carbon-carbon with uni-directional fibres has demonstrated in the prototype modules to suit the requirements with its superb properties of mechanical rigidity, large thermal conductivity, very long radiation length and low electrical resistivity.

The properties of carbon-carbon is summarized in Table 4 for a product available [3]. The product has a thermal conductivity of 700 W/m/K (in the fibre direction), nearly twice of Cu, and a young's modulus of 300 GPa (in the fibre direction), as strong as ceramics.

The specification of the bridge is shown in Figure 6. The bridge is machined, with a milling machine, so that the steps of the bridge are part of the original material in order to maximize the thermal conduction and the easiness of mechanical construction.

The surface of the bridge is coated with a polymer called Parylene of 10 μm thick for insulating the surface and improving reliability in handling. The surface of coating is roughened with a laser where adhesion is required. The coating is removed where an electrical and thermal conduction is required.

4.3 Glass pitch-adaptor

The basic pitch of input pads of the ASIC is 48 μm, while that of the silicon microstrip sensor is 80 μm. In order to make a simple parallel wire-bonding, a pitch-adaptor is used in front of the ASICs. Since a fine pitch of 48 μm is required, the pads and traces are fabricated on a separate piece with a thin-film technology: aluminium deposition on a glass substrate. The barrier metal between the glass and the aluminium is an important factor for the adhesion of the aluminium which is a proprietary knowledge of the vendor.

The specification of the pitch-adaptor is shown in Figure 7. The size of the pitch adaptor is 63 mm (L) x 2.7 mm (W) x 0.2 mm (T). The thickness of aluminium is 1 ~ 1.5 μm.

4.4 Surface mount components

The components of the hybrids are listed in Table 1. The capacitors are of the type X7R for the best temperature characteristics which has a capacitance change of 5% between -20 and +40 °C. The resistors are of metal film precision type.

The thermistors are those of R25 = 10 kΩ ± 1% and B = 3435K±1%. The temperature is readily calculated from the equation,

$$R = R25\exp\left(B\left(\frac{1}{T}+\frac{1}{T25}\right)\right) \quad (1)$$

where T is given in absolute temperature. T25 and R25 are the nominal temperature of 25 °C and the resistance at the temperature, respectively.

Loading of the components is shown in Figure 8.

5 Cu/Polyimide hybrid production and Quality Assurance

The barrel hybrids are delivered to the module assembly clusters as "passive component stuffed" hybrids, i.e., the ASIC stuffing, testing, and mounting the hybrids into modules is the responsibility of the clusters. The "passive component stuff" hybrids are to be fabricated in industry. The total quantity is rounded to be 2,500 pieces. Assuming various yields in fabrication steps, the required numbers of components are estimated and listed in Table 5.

5.1 Production of Cu/Polyimide flexible circuits

The Cu/Polyimide flexible circuits will be produced based on the specification described in the section 4.1. The quantity is 3,200. Along the fabrication of the circuits, a quality assurance (QA) will be carried out by vendor: (1) visual inspection for all products, (2) specimen tests for mechanical tolerance on outer dimensions, bonding pads/gap widths, plating thicknesses, and (3) integrity test of lines: open/short test for all products, and resistance measurement for samples.

5.2 Production of carbon-carbon bridges

The carbon-carbon (CC) bridges are fabricated based on the specification in the section 4.2 and delivered as a finished product. The fabrication quantity of the carbon-carbon bridges is 6,300. QA is made for: (1) mechanical tolerance of outer dimensions, (2) mechanical performance of Young's modulus and tensile strength for samples to be greater than 90% of specified values, (3) thermal performance of thermal conductivity to be greater than 600 W/m/K, and (4) electrical resistivity less than 25 mΩ measured on the two farthest windows.

5.3 Production of glass pitch-adaptors

The glass pitch-adaptor is made according to the drawing in the section 4.3 for the quantity of 5,700. QA is made for: (1) visual inspection of the mechanical finish, tolerance, and open/short of the traces for all products, (2) tape-peel test of the aluminium traces and (3) wire-bond pull test, for samples. The wire-bond pull strength is to be greater than 6 gr for the 30% height/distance ratio (H/L) setting.

5.4 Production of Cu/Polyimide/CC hybrids

This is the gluing process of the Cu/Polyimide flexible circuit and the CC bridges. This process produces "bare" hybrids, i.e., no components on the hybrid, yet. Two epoxy adhesive sheets are used: thermally conductive and electrically conductive. A set of small windows has been cut out on the surface of the bridges in order to improve the thermal and electrical contact between the carbon bridge and the ASICs. The area other than the windows is adhered with the thermally conductive adhesive sheet, ABLEFILM 563K-.002, 50 μm thick, alumina-filler filled, and at the windows with the electrically conductive sheet, ABLEFILM 5025E-.002, 100 μm thick, silver loaded [4]. The electrically conductive film is thicker so that the adhesive will fill up the through-holes in the hybrid.

Both adhesive films require curing at an elevated temperature at 125 deg.C for two hours. During the curing, the flexible circuit and the bridges are held and pressed together at 4 kg/cm^2 by a press jig.

QA is made for: (1) visual inspection for excess adhesives, residuals on the surface, and mechanical tolerance for the alignment and thickness, and (2) bows of the hybrid section at the room temperature, which are less than 75 μm in the long and the across directions, for all products.

5.5 Production of "Passive component stuffed" hybrids

This is the process soldering the surface-mount components (SMDs) and the connector on the hybrids and adhering two pitch-adaptors. About 50 SMD parts: resistors, capacitors, and thermistors as listed in Table 1, are installed on the hybrid. A component loading diagram is shown in Figure 8. Since a high temperature application, higher than 60 °C, is to be avoided after the adhesion of the flexible circuit and CC bridges, the solder reflow technique is eliminated in soldering the components. A method being used is to place and hold the components with a dot of epoxy, cure, and then apply soldering manually. The detail of the soldering process is being refined further incorporating the process involved in industry.

Two pitch-adaptors are glued on the hybrid by using a room temperature curing epoxy, Araldite 2011. No filler is used. The low viscosity epoxy makes the glue layer thin and without trapping air bubbles. The surface of the hybrid is protected beforehand with a masking tape in order to prevent contamination with the epoxy. The pitch-adaptor is positioned under a microscope to align the edge of the pitch-adaptors to the fiducial marks on the flexible circuit. The width of the line of the fiducial mark is 100 μm and alignment of the edge of the pitch-adaptor within the line width assures the position of the pitch-adaptor to be within ±50 μm.

QA is made for all hybrids: (1) visual inspection of component placement, solder fillet, surface contamination and residuals, (2) electrical measurement from the connector for the termination resistors and the capacitancies of the Vcc-GND and the Vdd-GND, and (3) a wire-bond pull test at the test pads to be greater than 6 gr for the 30% H/L setting.

5.6 Thermal cycling

The passive-component-stuffed hybrids are thermal-cycled between -30 and +60 °C for 5 times. QA is made for: (1) visual inspection for component loss, cracks, (2) mechanical tolerance for thickness and bows, (2) electrical performance of resistance, capacitance, and leakage current in the low and high voltage lines, the latter at 500 V.

6 Hybrid datasheet

A datasheet per hybrid is prepared summarising the QA in the section 5. The datasheet of a hybrid is shown in the appendix 7.1 as an example. An ATLAS parts identification number (atlas id) is given to the hybrid, as registered in the datasheet, and a barcode label is attached on the pigtail section of the hybrid. The datasheet will be uploaded to the database in a similar fashion as the detector datasheet.

7 Appendix

7.1 Hybrid datasheet

An example of the hybrid datasheet is appended in the following pages.

Hybrid datasheet	
ATLAS ID classification (KEK)	20220170100051
Mfr serial number	K4211
Overall Quality	Good
Parts:	
220 nF capacitors/batch	20220170111002
330 nF capacitors/batch	20220170112001
10nF/630V HV capacitors/batch	20220170113001
100 ohm resistors/batch	20220170114001
5.1K ohm resistors/batch	20220170115001
1K ohm resistors/batch	20220170116001
0 ohm resistors/batch	20220170117001
Semitec 103KT1608-1P thermistors/batch	20220170118001
Connector Samtec SFMC-140-L3-S-D/batch	20220170119001
Pitch adaptors/batch	20220170121001
Carbon-carbon bridges/batch	20220170122001
Conductive epoxy glue (Eotite P-102)/batch	20220170131001
Electrically non-conductive epoxy glue for hybrid/batch	20220170132001
Araldite+BN filler/batch	20220170133001
Attaching CC bridges to flex circuit/batch	20220170141001
Stuffing passive components/batch	20220170142001
1 Cu/Polyimide Flex circuits	Good
1.1 Visual inspection by vendor	Good
(1) Design features sizes and structures	Good
(2) Nicks and pin holes on conductor	Good
(3) Protrusions and residual conductor	Good
(4) Entrapped foreign materials	Good
(5) Wrinkles and fold lines	Good
(6) Air bubbles under cover film	Good
(7) Dents and delamination of conductor	Good
(8) Scratches on conductor	Good
(9) Discoloration and corrosion	Good
(10) Adhesive squeeze-out	Good
(11) Adhesive stain	Good
(12) Non-plating	Good
1.2 Integrity test of lines by vendor	Good
2 Cu/Polyimide/Carbon-bridge hybrid	Good
2.1 Visual inspection by vendor	Good
(1) Cracks	Good

(2) Alignment between flex circuit and Carbon-bridge	Good
(3) Fill up electrical conductive adhesive	Good
(4) Adhesive residuals	Good
(5) Adhesive squeeze-out	Good
2.2 Mechanical tolerance	Good
(1) Thickness measurement (microns) (6points)	Good
Link0 (average)	599.830000
Link1 (average)	597.830000
(2-1) Flatness measurement Bow (long)	Good
Link0 (<75)	29.727000
Link1 (<75)	36.600000
(2-2) Flatness measurement Bow (across)	Good
Link0 (<75)	42.705000
Link1 (<75)	40.815000
(2-3) Flatness measurement Twist	Good
Link0 (<100)	44.670000
Link1 (<100)	70.650000
3 Passive-component-stuffed hybrids	Good
3.1 Visual inspection by vendor	Good
(1) Passive-component alignment	Good
(2) Soldering	Good
(3) Residuals and foreign materials on surface	Good
3.2 Wire-bond pull test	
(1) pull strength (>6gr)	
4 Passive-component-stuffed hybrids with pitch adaptor	Good
4.1 Visual inspection by vendor	Good
(1) Pitch adaptor crack	Good
(2) Pitch adaptor alignment	Good
(3) Adhesive residuals	Good
(4) Adhesive squeeze-out	Good
5 temperature cycle tests	Good
5.1 Capacitance and impedance measurement by vendor	Good
Vcc-GND (microF) at 1KHz (4.0<x<4.8)	4.108700
Vdd-GND (microF) at 1KHz (4.0<x<4.8)	4.057000
HV-GND (kOhm) at 100Hz (30<X<36)	34.500000
HV-GND (kOhm) at 1KHz (9<X<11)	10.060000
HV-GND (kOhm) at 10KHz (5.7<X<7.7)	6.737000
HV-GND (kOhm) at 100KHz (5.1<X<7.1)	6.070300
5.2 temperature cycle test by vendor	Good
5.3 Visual inspection by vendor	Good
(1) Component loss	Good
(2) Cracks	Good
(3) Residuals and foreign materials on surface	Good
5.4 Mechanical tolerance	Good
(1) Thickness measurement(microns)(6points)	Good

Link0 (average)	602.830000
Link1 (average)	599.670000
(2-1) Flatness measurement Bow (long)	Good
Link0 (<75)	36.277000
Link1 (<75)	37.700000
(2-2) Flatness measurement Bow (across)	Good
Link0 (<75)	50.430000
Link1 (<75)	38.615000
(2-3) Flatness measurement Twist	Good
Link0 (<100)	57.880000
Link1 (<100)	47.100000
5.5 Resistance and capacitance measurement by vendor	Good
Vcc-GND (microF) at 1KHz (4.0<x<4.8)	4.129000
Vdd-GND (microF) at 1KHz (4.0<x<4.8)	4.081300
HV-GND (kOhm) at 100Hz (30<X<36)	34.400000
HV-GND (kOhm) at 1KHz (9<X<11)	10.060000
HV-GND (kOhm) at 10KHz (5.7<X<7.7)	6.738000
HV-GND (kOhm) at 100KHz (5.1<X<7.1)	6.070000
R27 (Ohm) (99<X<101)	100.060000
R28 (Ohm) (99<X<101)	100.020000
R29 (Ohm) (99<X<101)	99.960000
R30 (Ohm) (99<X<101)	99.980000
TM0 (kOhm) (9.8<X<10.2) at 25 degC	10.097000
TM1 (kOhm) (9.8<X<10.2) at 25 degC	10.150000
ASIC die pad No.1-No.6 (milliOhm) (<4)	3.600000
ASIC die pad No.7-No.12 (milliOhm) (<4)	3.600000
5.6 LV leakage current measurement by vendor	Good
Icc (nA) at 10V (<10)	9.000000
Idd (nA) at 10V (<10)	9.000000
5.7 HV leakage current measurement by vendor	Good
HV current (nA) at 500V (<10)	9.000000
6.Barcode and data sheet entry	Done

7.2 ASICs stuffing and replacing

After the receipt of the passive-component-stuffed hybrids, the module assembly sites attach ASICs on the hybrids. Some cautions and instructions are given here.

7.2.1 ASIC stuffing

The ASICs are glued on the chip pads with electrically conductive epoxy, Eotite p-102, in order to have a good thermal and electrical conduction. Four fiducial marks are prepared at the corner of the chip pad for aligning the ASICs. The bonding pads near the ASICs should be masked for not contaminating the bonding surface. Apply a correct amount of glue such that the glue extends full area of the ASICs and form a smooth fillet to the sides of the ASICs. When curing the epoxy at elevated temperature, e.g., at 50 °C for 2 hrs. or more, hold the hybrids at the steps of the bridges in order to prevent warping.

7.2.2 ASIC replacing

An ASIC can be replaced on the hybrid. A simple special jig for the ASIC replacement has been developed. It is made of a Cu block on a soldering iron. The Cu block is a 8 mm x 8 mm x 12 mm which has a trench of 6.5 mm wide and 0.3 mm deep where the ASIC can be fit and picked-off with vacuum-chucking. The block is attached on the tip of a conventional soldering iron. Heat the block at 250 °C. Apply the head to the ASIC. The glue underneath becomes soft in about 5 sec. By applying a twist to the ASIC, it can be picked off easily once the ASIC moves. A high power soldering iron (e.g., 20W) is to be used in order to have a heat capacity and heating time as short as possible. A photo of the jig is shown in Figure 10.

References

[1] Y. Unno, “High-density low-mass hybrid and associated technologies”, 6th Workshop on Electronics for LHC Experiments, pp 66-76, CERN 2000-010
[2] M. Tyndel, et al., “Internal Design Review of the SCT Barrel Hybrids”, reference id, 5 July, 2000
[3] A product is available from Nippon Mitsubishi Oil Corporation, catalog no. NCC-AUD28
[4] These adhesive sheets are made by ABLESTICK co. Ltd..

Table 1
List of components

parts No.	# of pieces	dimensions (mm)	specifications	products
U1 ~ U12	12	6.55x8.40x0.5	ABCD3T chip	
C1 ~ C28	28	1.6x0.8x0.8	Ceramic capacitor 220 nF, 10V,	Murata GRM39-X7R-224-K-10
C51 ~ C58	8	3.2x1.6x1.25	Ceramic capacitor 330 nF, 25 V,	Murata GRM42-6-X7R-334-K-25
C71 ~ C75	5	3.2x1.6x1.25	Ceramic capacitor 10 nF, 630 V	Murata GHM1530-B-103-K-630
R27 ~ R30	4	1.6x0.8x0.8	Resistor, 100Ω	
R33, R34	2	1.6x0.8x0.8	Resistor, 5.1 kΩ	
R35	1	1.6x0.8x0.8	Resistor, 1 kΩ	
R36	1		jumper wire	
TM1, TM2	2		Thermistor	Semitec 103KT1608-1P
CON	1		Connector, 2x18pins, 1.27mm pitch,	Samtec SFMC-120-L3-S-D or 0.05”x0.05” 40 square-pins female
PA	2		pitch adaptor	pa4880

Table 2
Pin assignment of the hybrid connector.

1	+bias(HV)	10	analog ground	19	digital ground	28	com0-bar
2	+bias(HV)	11	V_{CC}	20	digital ground	29	clock0
3	NC	12	analog ground	21	V_{DD}	30	clock0-bar
4	NC	13	VCC	22	V_{DD}	31	led
5	-bias(ag)	14	analog ground	23	digital ground	32	led-bar
6	-bias(ag)	15	com1	24	digital ground	33	ledx
7	tempret	16	com1-bar	25	reset	34	ledx-bar
8	analog ground	17	clock1	26	select	34	temp1
9	V_{CC}	18	clock1-bar	27	com0	36	temp2

Table 3
Electrical properties of the Cu/Polyimide barrel hybrid

Trace/Plane	Capacitance [pF]		Resistance [mΩ]	
	bare flex circuit	with bridge	pigtail section	rest of hybrid section
Analog ground (AGND)	--	--	13	24
Digital ground (DGND)	--	--	13	46
Analog power (Vcc)	1.2	1.9	15	46
Digital power (Vdd)	0.9	0.9	15	46
Command bus line	39		500	1700
Data/token longest lines	32		1800	
Data/token short lines	3		100	
Values are based on measurement. Errors are estimated to be about 10%.				

Table 4
Properties of Carbon-carbon

Material	Uni-directional fibres
Thermal conductivity (fibre direction) [W/m/K]	700 ± 20
Thermal conductivity (transverse to fibres) [W/m/K]	35±5
Density [g/cm^3]	1.9
Young’s modulus (fibre direction) [GPa]	294
Tensile strength (fibre direction) [MPa]	294
Thermal expansion coefficient (CTE) (fibre direction) [ppm/K]	-0.8
Thermal expansion coefficient (CTE) (transverse to fibres) [ppm/K]	10
Electrical resistivity (fibre direction) [Ωm]	2.5 x 10^{-6}

Table 5
Required numbers of components (numbers rounded to 100)

“passive component stuffed” hybrids	2500
Cu/Polyimide flexible circuits	3200
Carbon-carbon bridges	6300
Pitch-adaptors	5700
SMDs and connector (set)	3000

Figure captions:

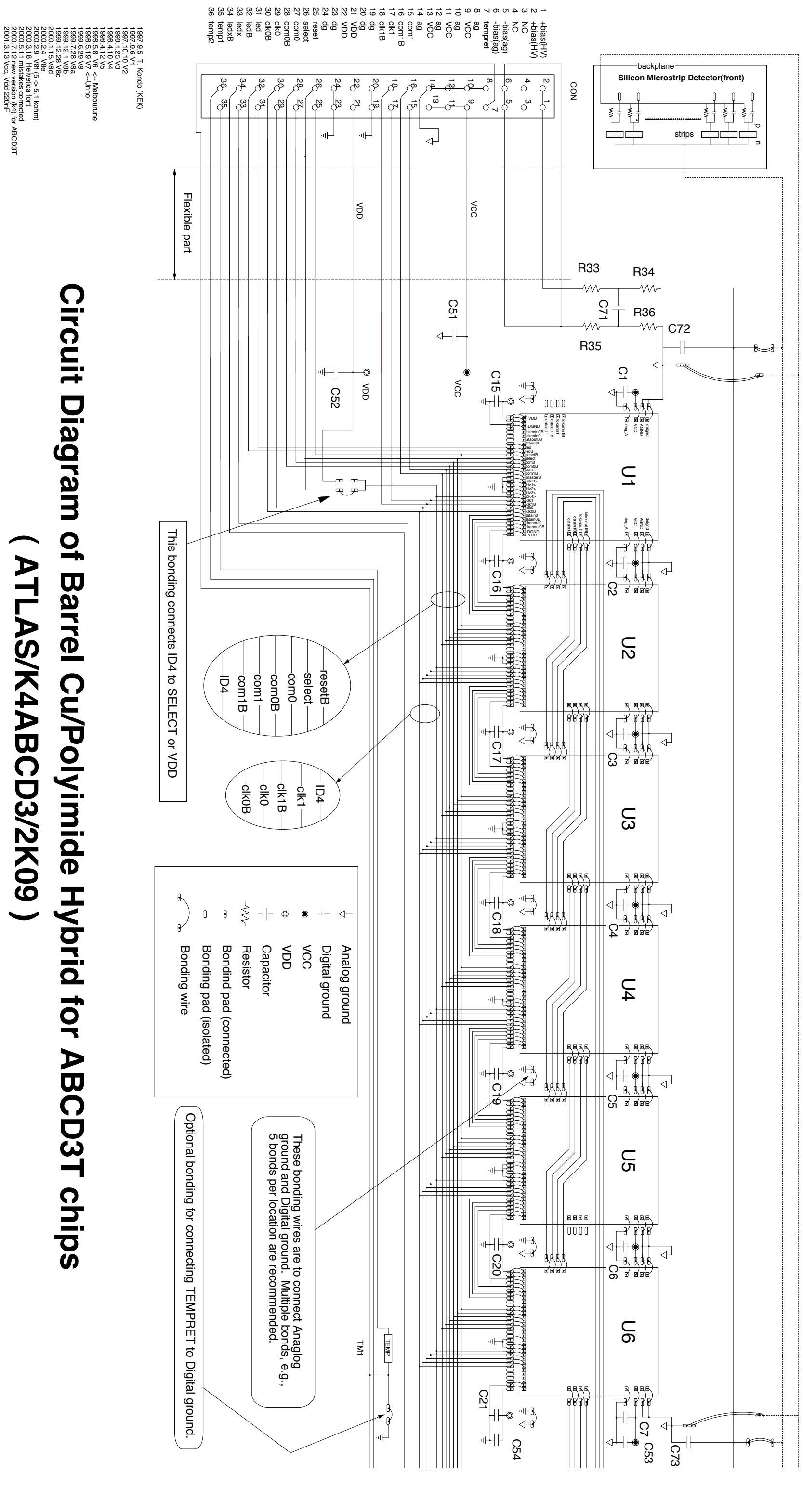


Figure 1 Schematic circuit diagram of the barrel hybrid (version 4), connector side

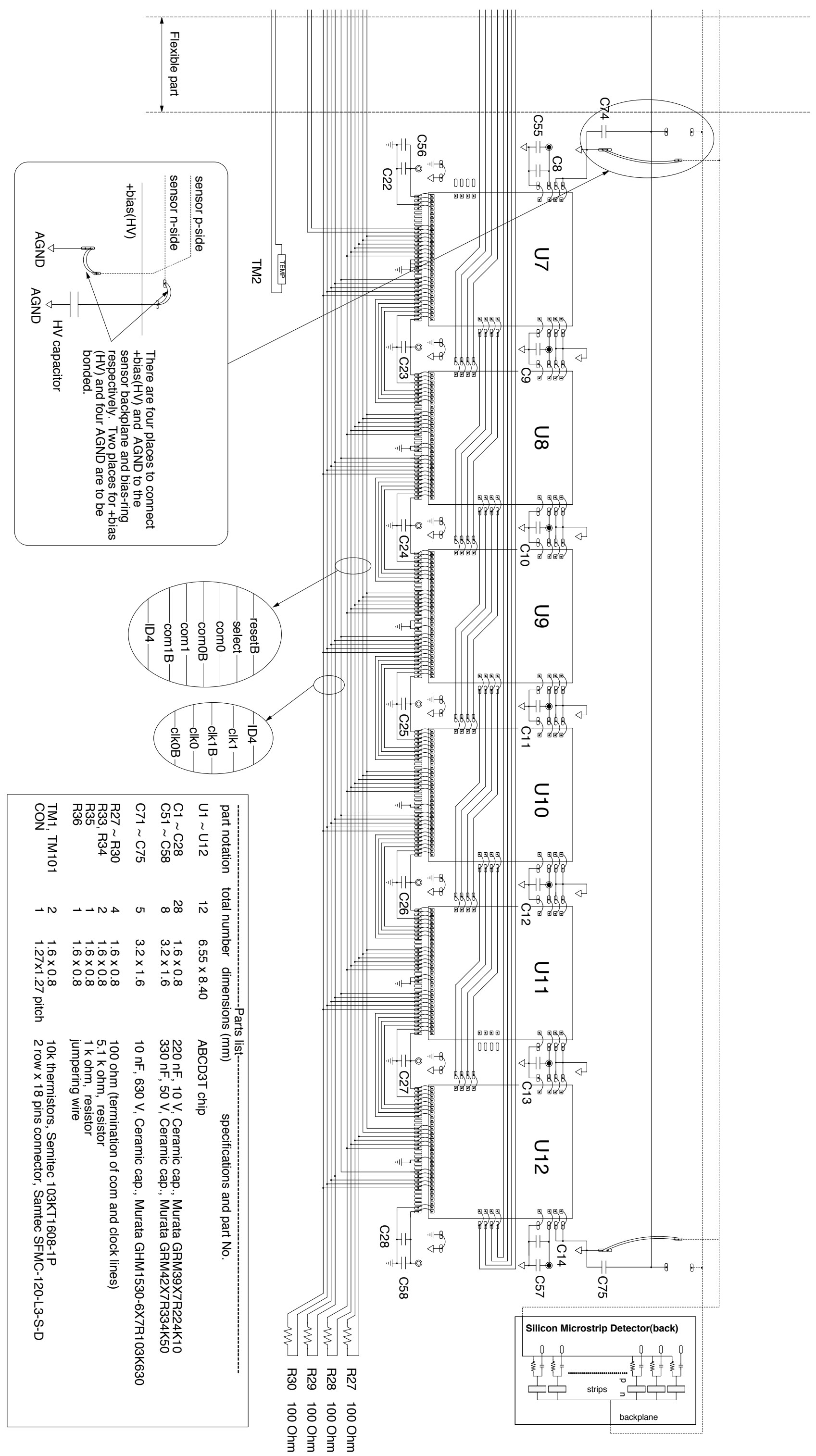


Figure 2 Schematics circuit diagram of the barrel hybrid (version 4), far-end side

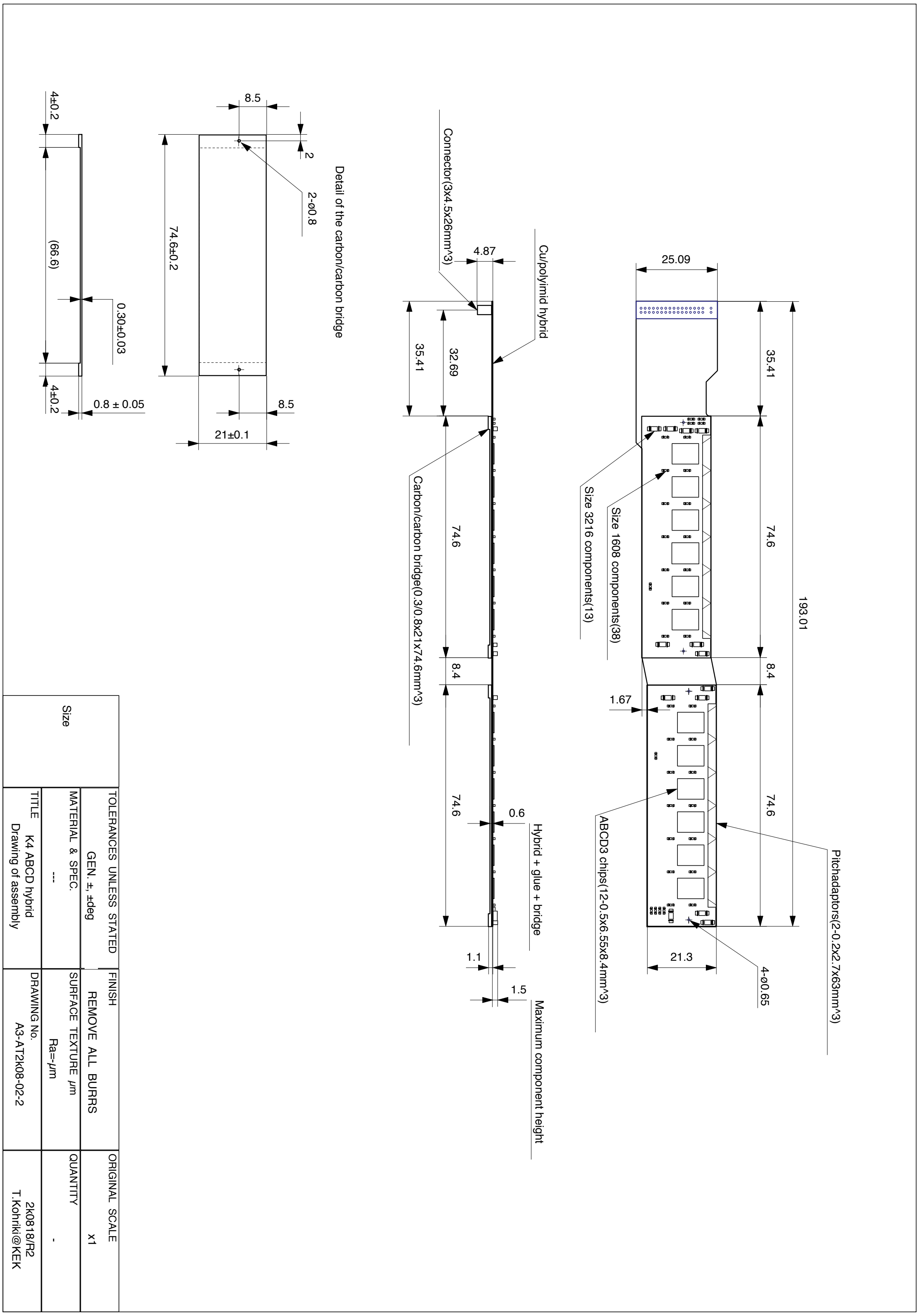
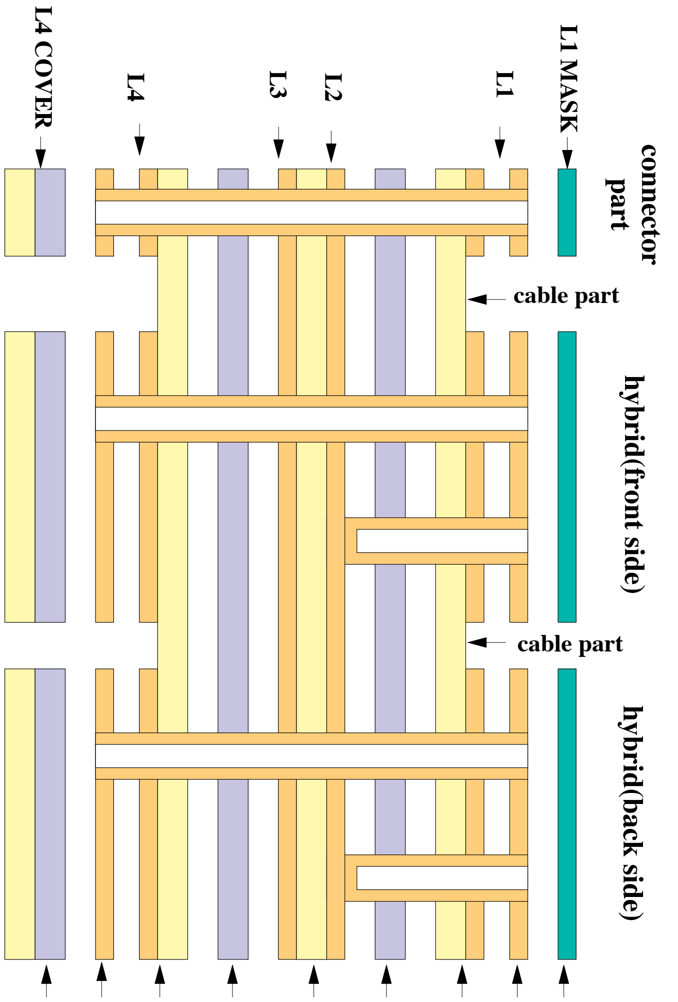


Figure 3 Dimensions and profile of the Cu/Polyimide barrel hybrid (version 4)



Cu/Polyimide surface build-up/high density interconnect technology:
Through-hole 300 μm dia., Land 500 μm dia.
Lasar-via 150 μm dia., Land 300 μm dia., surface build-up
Min. line width 80 μm, min. gap 80 μm

Layer Structure of the Cu/Polyimide Flexible circuit version-4

Material	Thickness μm
Photo-solder resist	20
Through-hole plating (50% mesh)	20
Polyimide-Copper(single-sided) 1/3 oz(12μm)Cu, 1 mil PI, Adhesive-less	37
Adhesive	25
Polyimide-Copper(double sided) 1/3 oz Cu, 1 mil PI, 1/3 oz Cu Adhesive-less	49
Adhesive	25
Polyimide-Copper(single-sided) 1/3 oz(12μm) Cu, 1 mil PI, Adhesive-less	37
Through-hole plating (50% mesh)	20
Polyimide cover film 1/2 mil, Adhesive 33 μm	46
Total : circuit part cable part	279 149
Surface treatment non-electroysis gold plating (0.3 μm Au, < 3 μm Ni)	

Figure 4 Layer structure of the Cu/Polyimide flex circuit of the barrel hybrid (version 4)

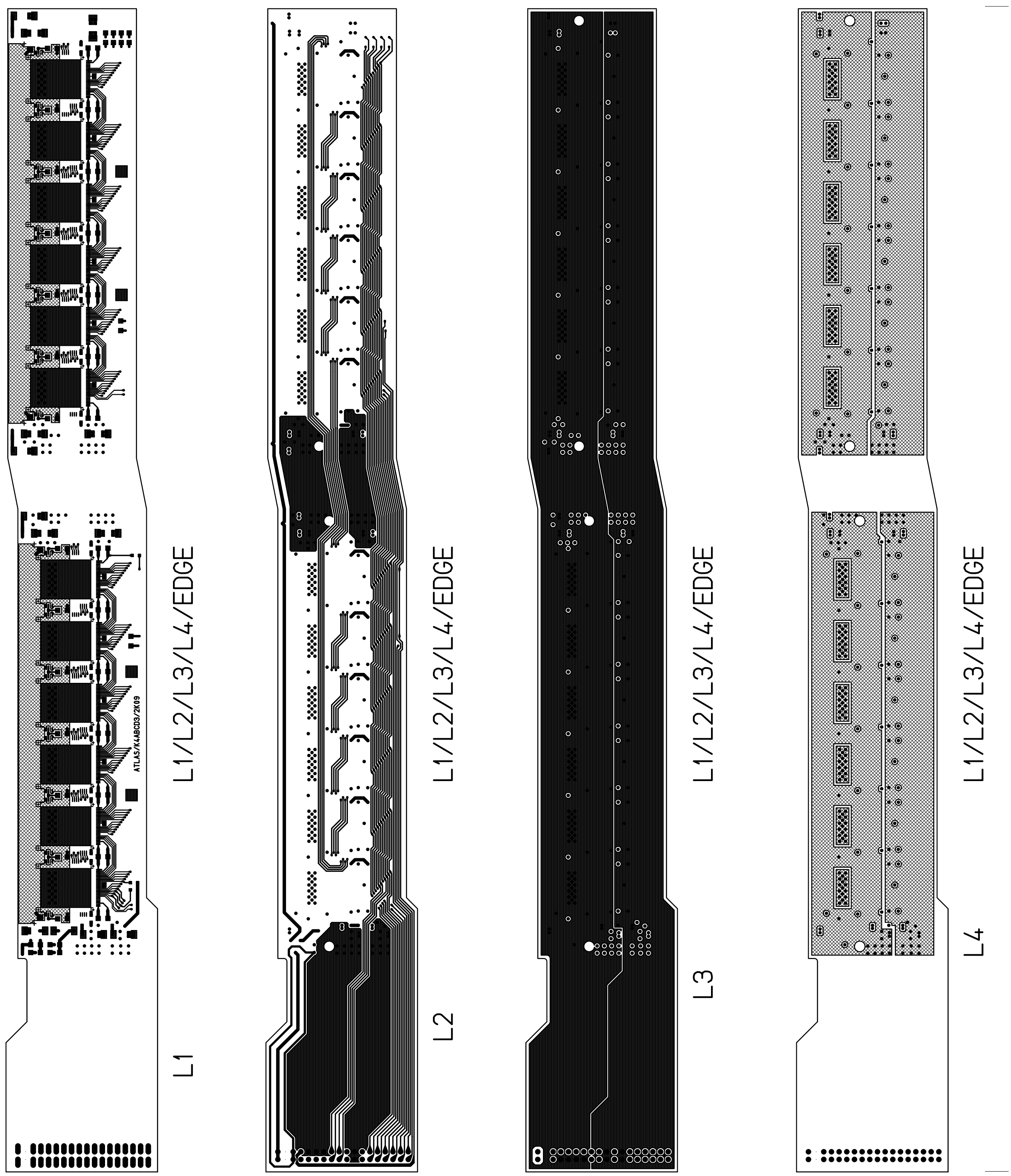
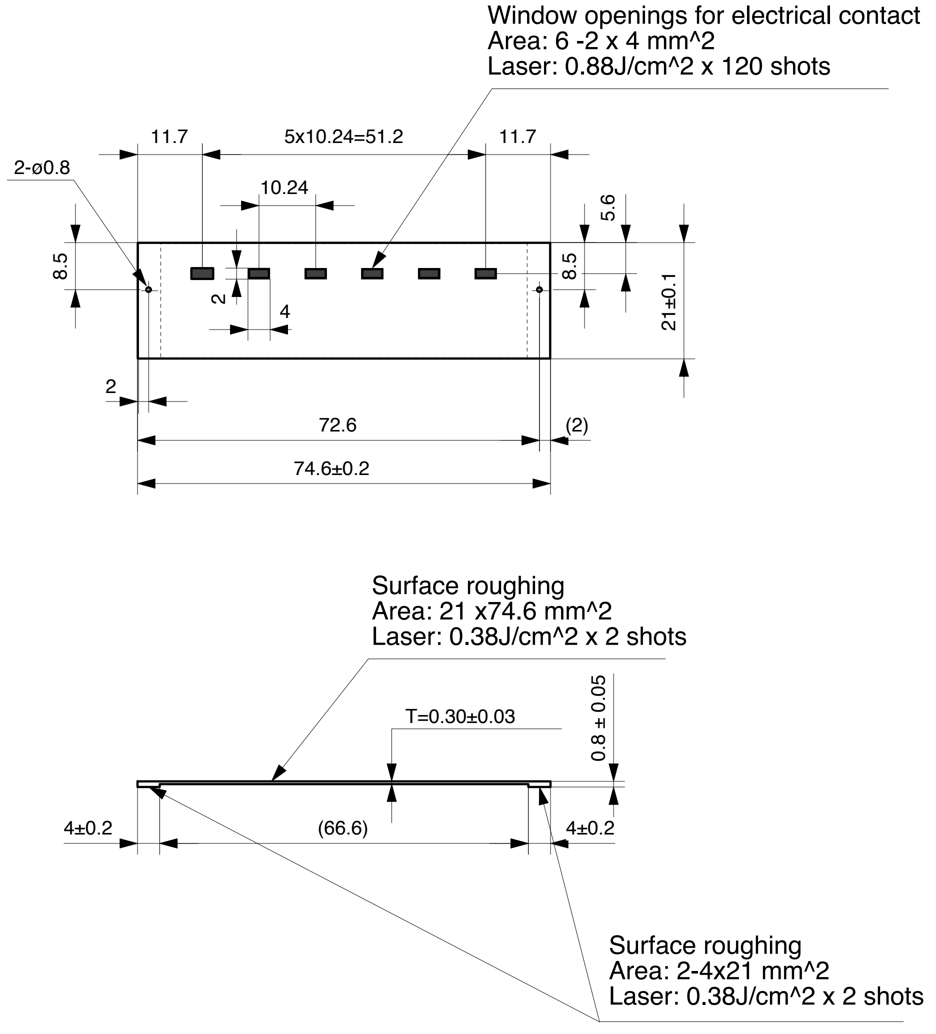


Figure 5 Layer layouts of: top traces (L1), bus traces (L2), ground planes (L3), and power planes (L4)



Laser processing: Tolerance ±0.3

Note the location of two ø0.8 holes

	TOLERANCES UNLESS STATED GEN. ±0.1	FINISH REMOVE ALL BURRS	ORIGINAL SCALE 1/1
	MATERIAL & SPEC. CC-bridge+Parylene(10μm)	SURFACE TEXTURE μm STOCK(UNLESS STATE)	QUANTITY - pieces
	TITLE CC-bridge+Parylene+Laser bridge2000	DRAWING No. A4-AT2k07-02	2k0201R0 T.Kohriki@KEK

Figure 6 Hybrid bridge made of carbon-carbon

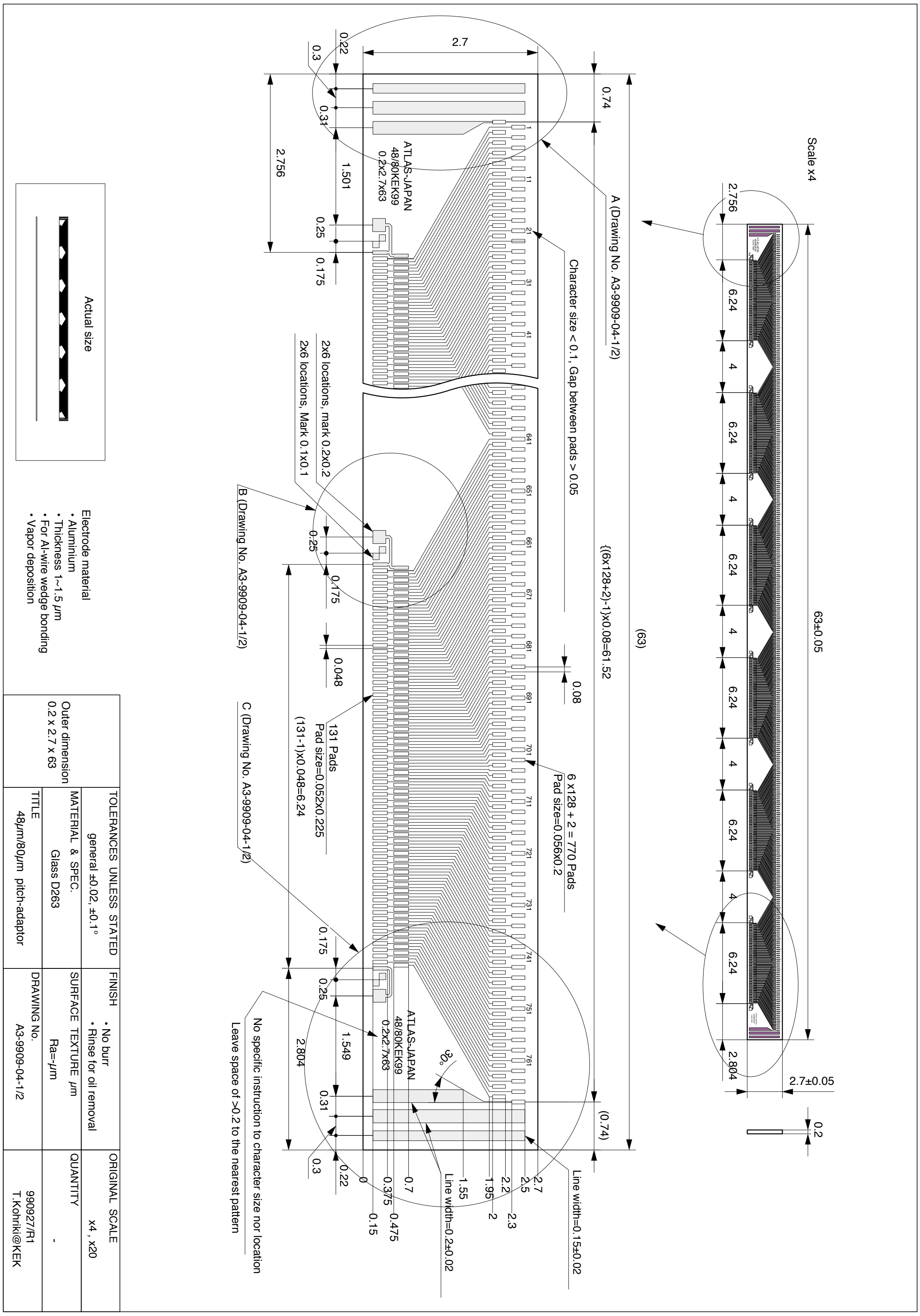


Figure 7 Glass pitch adaptor

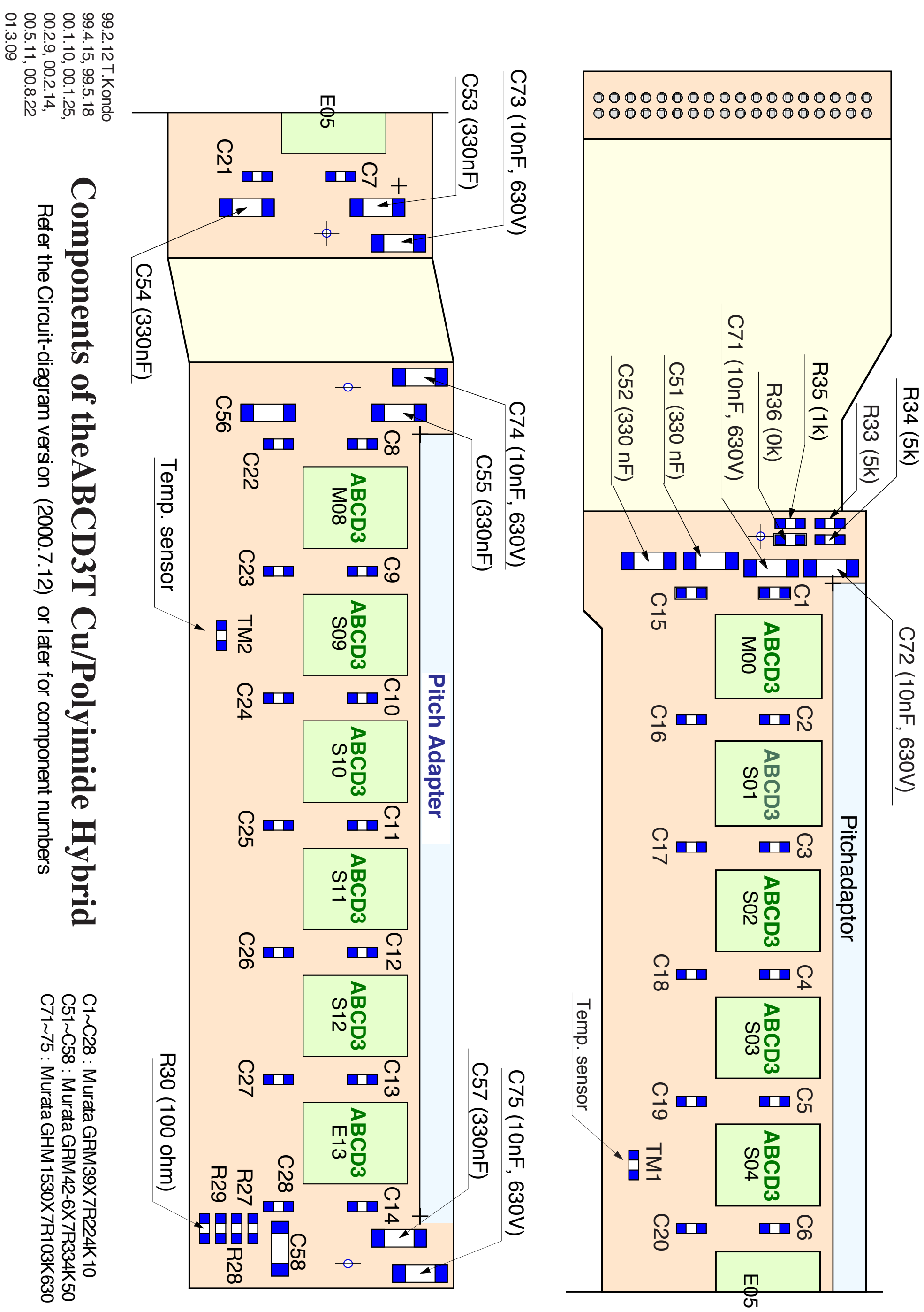


Figure 8 Component loading diagram

KhybridXo01feb26.xls

Cu/Polyimide hybrid 12μm Copper, version4

Normalise to 74.6 x 21 mm^2 = **1566.6**

Item	No. off	Basic x (mm)	Basic y (mm)	Basic area	Less area	Actual area	Scaled area	Thickness (mm)	Thickness mea (mm)	Scaled thickness	X0 (mm)	Rad len (%)	Density (g/cm^3)	Weight (gm)	Summed weight (gm)	Measured weight (gm)
Main hybrids (2-in-1)	2	74.6	21			1566.6		0.267	0.233	0.2203	86.13	0.621		1.681	2.03	2.04
Gold flash(0.4μm)	2	74.6	21	1566.6	881	686	0.438	0.000		0.0002	3.35	0.010	19.3	0.011		
Nickel plating(2μm)	2	74.6	21	1566.6	881	686	0.438	0.002		0.0009	14.7	0.012	8.845	0.024		
Photoresist (20μ) layer	2	74.6	21	1566.6	567	1000	0.638	0.020		0.0128	357.5	0.007	1.136	0.045		
L1:Copper(12μm)+TH-plating(13μm) (60% hash)	2	74.6	21	1566.6	881	686	0.438	0.025		0.0109	14.3	0.153	8.93	0.306		
Polyimide+adhesive (25μ+25μ) layer	2	74.6	21	1566.6	0	1567	1.000	0.050		0.0500	357.5	0.028	1.136	0.178		
L2:Copper tracking(12μm)	2	74.6	21	1566.6	1268	298	0.190	0.012		0.0023	14.3	0.032	8.93	0.064		
Polyimide layer (25μ)	2	74.6	21	1566.6	0	1567	1.000	0.025		0.0250	357.5	0.014	1.136	0.089		
L3:Copper gnd plane(12μm)	2	74.6	21	1566.6	112	1455	0.929	0.012		0.0111	14.3	0.156	8.93	0.312		
Polyimide+adhesive (25μ+25μ) layer	2	74.6	21	1566.6	0	1567	1.000	0.050		0.0500	357.5	0.028	1.136	0.178		
L4:Copper(12μm)+TH-plating(13μm) (60% hash)	2	74.6	21	1566.6	873	694	0.443	0.025		0.0111	14.3	0.155	8.93	0.310		
Polyimide cover+adhesive (13μ+33μ) layer	2	74.6	21	1566.6	0	1567	1.000	0.046		0.0460	357.5	0.026	1.136	0.164		
Interconnect	1	9	21			189		0.149	0.141	0.0173	90.43	0.020		0.058		
Polyimide+adhesive (25μ+25μ) layer	1	9	21	189.0	0	189	0.121	0.050		0.0060	357.5	0.002	1.136	0.011		
Copper tracking	1	9	21	189.0	72	117	0.075	0.012		0.0009	14.3	0.006	8.93	0.013		
Polyimide layer	1	9	21	187.1	0	187	0.119	0.025		0.0030	357.5	0.001	1.136	0.005		
Copper gnd plane	1	9	21	189.0	14	176	0.112	0.012		0.0013	14.3	0.009	8.93	0.019		
Polyimide+adhesive (25μ+25μ) layer	1	9	21	189.0	0	189	0.121	0.050		0.0060	357.5	0.002	1.136	0.011		
Pig tail	1	30	24.5			735		0.149	0.141	0.0658	87.78	0.080		0.228		
Polyimide+adhesive (25μ+25μ) layer	1	30	24.5	735.0	42	693	0.442	0.050		0.0221	357.5	0.006	1.136	0.039		
L2:Copper tracking(12μm)	1	30	24.5	735.0	192	543	0.347	0.012		0.0042	14.3	0.029	8.93	0.058		
Polyimide plane	1	30	24.5	735.0	42	693	0.442	0.025		0.0111	357.5	0.003	1.136	0.020		
L3:Copper gnd plane(12μm)	1	30	24.5	735.0	87	648	0.414	0.012		0.0050	14.3	0.035	8.93	0.069		
Polyimide/adhesive (25μ+25μ) layer	1	30	24.5	735.0	0	735	0.469	0.050		0.0235	357.5	0.007	1.136	0.042		
Connector pad	1	5	25			125		0.267		0.0173	110.15	0.019		0.060		
Gold flash(0.4μm)	1	5	25	125.0	80	45	0.029	0.000		0.0000	3.35	0.000	19.3	0.000		
Nickel plating(2μm)	1	5	25	125.0	80	45	0.029	0.002		0.0001	14.7	0.000	8.845	0.001		
Photoresist (20μ) layer	0	5	25	125.0	0	125	0.080	0.020		0.0016	357.5	0.000	1.136	0.000		
L1:Copper(12μm)+TH plating(13μm)	1	5	25	125.0	80	45	0.029	0.025		0.0007	14.3	0.005	8.93	0.010		
Polyimide/adhesive (25μ+25μ) layer	1	5	25	125.0	0	125	0.080	0.050		0.0040	357.5	0.001	1.136	0.007		
L2:Copper tracking (12μm)	1	5	25	125.0	105	20	0.013	0.012		0.0002	14.3	0.001	8.93	0.002		
Polyimide layer(25μm)	1	5	25	125.0	0	125	0.080	0.025		0.0020	357.5	0.001	1.136	0.004		
L3:Copper gnd plane (12μm)	1	5	25	125.0	75	50	0.032	0.012		0.0004	14.3	0.003	8.93	0.005		
Polyimide/adhesive (25μ+25μ) layer	1	5	25	125.0	0	125	0.080	0.050		0.0040	357.5	0.001	1.136	0.007		
L4:Copper(12μm)+TH plating (13μm)	1	5	25	125.0	80	45	0.029	0.025		0.0007	14.3	0.005	8.93	0.010		
Polyimide cover+adhesive (13μ+33μ) layer	2	5	25	125.0	0	125	0.080	0.046		0.0037	357.5	0.002	1.136	0.013		
Substrate	2	74.6	21			1566.6		0.337		0.3108	199.42	0.338		2.345		2.368
CC	2	74.6	21	1566.6	0	1567	1.000	0.300		0.3000	218.10	0.275	2.0385	1.916		
CC "step"	4	4	21	84.0	0	84	0.054	0.500		0.0268	218.10	0.049	2.0385	0.342		
Parylene top layer (10 μm)	2	74.6	21	1566.6	105	1462	0.933	0.010		0.0093	286	0.007	1.42	0.042		
Parylene bottom layer (10 μm)	2	74.6	21	1566.6	0	1567	1.000	0.010		0.0100	286	0.007	1.42	0.044		
Substrate-hybird adhesive	2	74.6	21			1566.6		0.100		0.0500	277.80	0.072		0.312		
Conductive adhesive (7% area)	2	74.6	21	1566.6	1462	105	0.067	0.050		0.0034	42.77	0.016	3.68	0.039		
Thermal adhesive (93% area)	2	74.6	21	1566.6	105	1462	0.933	0.050		0.0466	165.65	0.056	1.87	0.273		
Total	**1**					**1566.6**				**0.681**	**59.27**	**1.150**		**4.683**		

k4polymer

Figure 9 Radiation length and weight of the barrel hybrid (version 4)

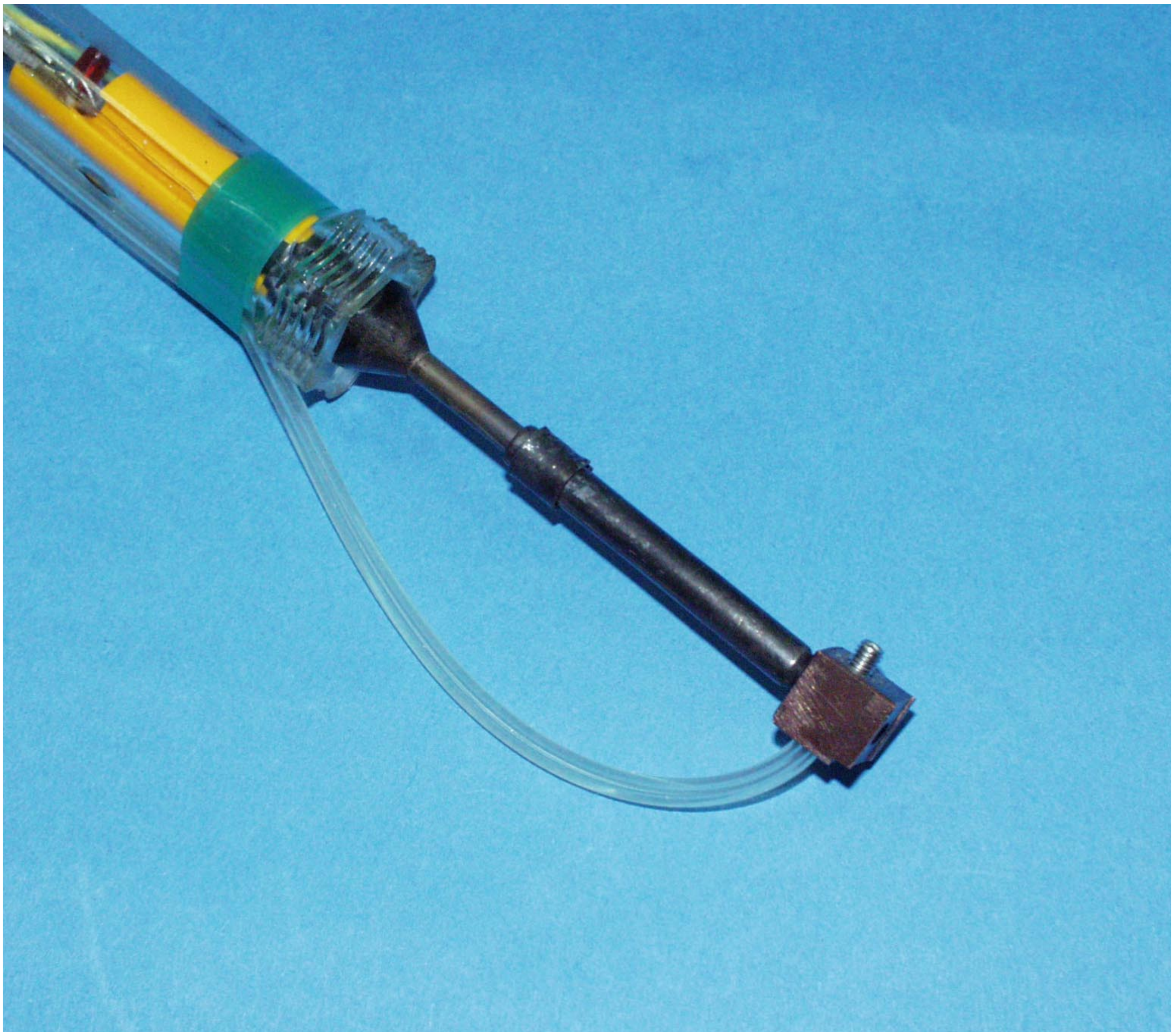


Figure 10 An ASIC replacement jig