SCT barrel hybrid fabrication

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SCT barrel hybrid fabrication

abstract

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Distribution List

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History of Changes

Rev. No.	***Date***	***Pages***	***Description of changes***
A	dd/mm/yy	All	First version
	23/08/00	7	Table 2
	23/08/00	5	Electrically conductive epoxy revised
	09/03/01		Revised title and texts, and added catalogue names of epoxies

1 Introduction

The ATLAS SCT barrel module is a double sided module. Two top-side detectors and the other two bottom-side detectors are glued back-to-back with a heat conducting and structural core of highly-thermally-conductive material. A readout hybrid is placed near the middle of the module, bridging over the silicon detectors of the top and the bottom side. The hybrid is made of copper polyimide laminated flex circuit with four metal layers. Two cable sections, the pigtail part from the topside hybrid to the connector to the external world and the wrap-around part between the top- and the bottom-side hybrids are continuous construction of the middle two layers. This one-piece construction eliminates the connection between the hybrids and the cable sections and improves reliability. The cable section of two metal layers is flexible enough to wrap around the module in a small radius.

The hybrid area of the flex circuit is glued to a low-mass and highly thermally conductive carbon substrate in order to reinforce the mechanical rigidity, specially for Aluminium-wire ultrasonic wedge-bonding, and the thermal and electrical conduction. The substrate is made of carbon-carbon with unidirectional fibres. Specification of the carbon-carbon bridge is available as a separate document [1].

The top- and the bottom-hybrid carry 6 ABCD readout chips [2], respectively. In order to match the pitch of ATLAS98 sensors (80 µm) and the input pad pitch of the ABCD chips (48 µm), a pair of pitch-adaptors made of Al.-traces-on-glass is glued on the hybrid.

The Cu/Polyimide flex circuits are to be produced in industry. The steps of gluing the carbon bridges, and stuffing passive components and gluing the pitch-adaptors are to be done in industry in separate steps. After passing through the hybrid quality assurance tests for the passive component-stuffed hybrids, the hybrids are to be shipped to the module assembly sites for stuffing ABCD ASIC chips and assembling into modules. Stuffing and eventual replacement of the ASIC's are responsibility of the module assembling site.

2 Production of flex circuits

About 2,500 flex circuits are to be produced in industry. Quality assurance of the flex circuits are to be done in industry and specified in the document [xx]. The major items of the QA are:

Tests by manufacturer are:

1. Visual inspection for all products
2. Specimen tests for etching
3. Integrity test of lines: electrical open/short test for all products, and resistance measurement by sampling

3 Gluing carbon-carbon bridges

A pair of carbon-carbon bridges are glued on the flex circuit in order to reinforce the mechanical rigidity and the thermal and electrical conduction. The surface of the carbon-carbon bridge is covered with a polymer called Parylene for protection and electrical insulation. Since the surface of Parylene has a very low friction, the surfaces where adhesives are to be applied are roughed by laser for reliable glue adhesion. The area where the thermal and electrical conduction are required are cut out by laser exposing the surface of carbon-carbon. Six small windows are cut out where the ASIC's are sitting on top.

A thin-film type epoxy with an alumina filler, e.g. ABLEFILM 563K-.002, is used for gluing the carbon-carbon to the flex circuits except the windows for the thermal and electrical conduction. The thermal and electrical conduction are provided with a thin-film epoxy with a silver filler, e.g. ABLEFILM 5025E-.002. For these samples of adhesives, a heated curing process is applied at the temperature of 125 °C of two hours. In this heated curing process, the flex circuit and bridges are compressed uniformly with a press jig. In order to compensate the elongation of the flex circuit relative to the carbon-carbon bridge at the high temperature, the jig has a curved surface at pressing. The CTE of the flex circuit is about 25 ppm/K and that of carbon-carbon bridge is -0.8 ppm/K. At the room temperature, the length of the flex circuit is made matching with the length of the bridge and thus the stress is to be minimum at the room temperature, in order to have the least bowing.

QA: at the room temperature

1. Visual inspection: cracks, alignment, fill-up in the thermal through-holes, adhesive residual, adhesive squeeze-out
2. Thickness (at hybrid): 620 ± 30 µm
3. Sagitta: 75 µm (along) and 75 µm (across)
4. Electrical resistance: 4 mΩ (ASIC pads between 1 and 6 and 7 and 12)

4 Stuffing passive components and gluing pitch-adaptors

4.1 Soldering surface-mount components (SMD parts)

About 50 SMD parts, listed in Table 1, are to be stuffed. The physical locations of the components are shown in the component loading drawing, Figure 1. The electrical connections of components and ASIC's are shown in the circuit diagram, Figure 2 (topside hybrid) and Figure 3 (bottom-side hybrid). The full area of the backside of carbon-carbon bridge of hybrid must be held flat and fixed on an appropriate jig in soldering the components. The surface of the hybrid other than the component stuffing are desirable to be masked with a masking tape or sheet.

QA:

1. Visual inspection: component alignment, soldering finish, residuals and foreign materials

4.2 Soldering connectors

A double-row 1.27mm x 1.27 mm connector of 36 contacts, Samtec SFMC-120-L3-S-D, is to be soldered at the end of the pigtail cable section. Excess tail of pins will be trimmed.

QA:

1. Visual inspection: soldering finish, residuals and foreign materials
2. Resistance, capacitance and impedance measurement, through connector pins

   Resistance: R27, R28, R29, R30 - 100 ± 1 Ω, TM1, TM2 (at 25 °C) - 10 ± 0.2 kΩ
   Capacitance: Vcc-GND, Vdd-GND, at 1KHz - 4.2 ± 20% µF
   Impedance: HV-GND at 100, 1k, 10k, 100k Hz - 33, 10, 6.7, 6.1 ± 10% kΩ

4.3 Gluing pitch-adaptors

The difference of the pitches of the ASIC's and the silicon microstrip sensors is absorbed with a pitch-adaptor shown in Figure 4. Since the ASIC's are to be attached in the module assembling sites, pitch-adaptors are to be glued before the ASIC mounting. For gluing the pitch adaptor, an epoxy of room temperature curing and relatively low viscosity without a filler, e.g. Araldite 2011, is applied so as to make glue layers as thin as possible without trapping air bubbles. Guided with the fiducial marks on the flex circuit, the pitch adaptors are positioned and pressed carefully with a jig. The hybrid surface is to be covered with a masking tape to protect from overflowing of the glue.

QA:

1. Visual inspection: crack, alignment, residuals and excessive squeeze-out

4.4 Thermal cycling

The hybrids completed up to this stage are subject to 5 times of thermal cycling, between -30 and +60 °C. During the thermal cycling, the hybrid is to be held properly at the carbon-carbon bridge ends/steps.

After thermal cycling, the final QA is to be made before shipping to the module assembly sites.

1. Visual inspections: repeating QA of the sections 4.1 to 4.3
2. Mechanical tolerances: repeating QA of the section 3
3. Resistance, capacitance and impedance measurement, through connector pins: repeating QA of the section 4.2
4. LV leakage current at 16 V and HV leakage current at 500V - less than 10 nA
5. Statistical analysis: make histograms of numerical values and analyse the distributions

5 Stuffing ASIC's

After receipt of the passive-component-stuffed hybrids, fabrication of the hybrids and assembling into modules proceed in the following steps:

1. Glue ASIC's with silver-loaded conductive epoxy, e.g. Eotite P-102, and cure
2. Wire-bond backend pads of ASIC's and AGND-DGND pads
3. Quality assurance tests of ASIC stuffed hybrids
4. Align and glue the hybrid on the sensor-baseboard assembly
5. Wire-bond sensor-hybrid input channels and HV connections
6. Quality assurance tests of modules

5.1 Gluing ASIC's

In order to enhance heat and electrical conduction, a number of through-holes are prepared in the area where the ASIC is mounted. The ASIC's are to be glued with an electrically conductive epoxy to have good heat and electrical, though AC coupling, conduction. The full backside area of the ASIC is to be glued, with a proper fillet to appear in the side of the ASIC die.

The condition required for the electrically conductive epoxy are:

1. Curing below 80 °C. This is because the glass transition temperature of the epoxy for gluing the flex circuit and the bridge is about 80 °C. The environmental temperature is better to be kept well below this temperature for any environmental heat-up, specially when the

hybrid is not fixed in the module.

2. Low impurity content of Cl and Na for long-term performance of the ASIC's. Epoxy which is classified as "die-attach" has usually Cl<100 ppm and Na<10 ppm.

KEK has been using an low-temperature curing electrically conductive epoxy, Eotight P-102, made by Eon Chemie Co. Ltd in Japan, which cures at 50 °C/2 hrs.

5.2 Wire-bondings

Electrical connections between the ASIC's and hybrids are to be made with supersonic aluminium wire-wedge bondings with a 25 µmϕ wire. In some pads, more than single wire is recommended to ensure low resistance/impedance connection and improve reliability. They are:

1. GND (digital-, analog-, ring-a, det-,...), Vcc, Vdd pads: at least 2 wires per pad if possible
2. AGND-DGND stitching pads: as many wires as possible, e.g. 5 wires/pad,
3. Detector bias connections in the module: at least 2 wires per pad. Sensor backplane is to be connected at two locations from the topside hybrid.The backplane bias connection is done only at the topside hybrid, since the baseboard has only those contacts at the topside facings. The strip bias connection is to be made at four locations: two from topside and two from bottom-side hybrids. \

The wire-bonding detail is described in a separate document [3].

5.3 Quality assurance of the hybrids and the modules

Quality assurance of the ASIC stuffed hybrids and the modules is to be described in a separate document.

5.4 Other recommendations

There are miscellaneous recommendation in order to keep quality of the fabrication:

1. Dry up the hybrids in a low humidity environment (<50% RH) before soldering
2. Mask the wire-bonding pads when soldering not to contaminate the bonding surface
3. Do not burn out the hybrid with a soldering iron. The spec is <10 sec at 260 deg.C. The higher the temperature, the shorter the time (than 10 sec).
4. When wire-bonding, note that the width of the pads on hybrid which are mating with the output pads of the chip is the narrowest, 80 ~ 100 µm
5. Recommend to confirm the performance of the chips before wire-bonding between the chip and the pitch-adaptor
6. Keep the masking tape on the pitch-adaptor until the wire-bonding between the chips and the pitch-adaptor occurs

6 ASIC replacement

ASIC replacement has been tested successfully. A special jig for the ASIC replacement has been developed. The jig's tip is a 8 mm x 8 mm x 12 mm copper block which has a trench of 6.5 mm wide and 0.3 mm deep where the ASIC is to be fit and held with vacuum-chucking. The tip is attached to the tip of a conventional soldering iron. A photo of the jig is shown in Figure 5. The ASIC to be replaced can be heated locally with the jig without damage to the flex circuit and to the other components nearby. We recommend to use a high power soldering iron (e.g. 20W) in order to make the heating time as short as possible.

Apply the tip to the ASIC, with the tip temperature of about 250 deg.C. The glue underneath the ASIC would become soft in about 5 sec. Once the ASIC moves by applying small twist to the ASIC, the ASIC can be removed easily.

References

[1] T. Kohriki et al., Specification of carbon-carbon bridge
[2] ABCD3T Chip Specification Version V1.2, July 24, 2000
[3] T. Kohriki et al., ATLAS SCT Barrel module wire-bonding scheme

Table 1
List of components

parts No.	# of pieces	dimensions (mm)	specifications	products
U1 ~ U12	12	6.550 x 8.400	ABCD2T chip (V2.1)	
C1 ~ C28	28	1.6 x 0.8 x 0.8	Ceramic capacitor 220nF, 10V,	Murata GRM39X7R224K10
C51 ~ C58	8	3.2 x 1.6 x 1.25	Ceramic capacitor 330 nF, 25 V,	Murata GRM42-6X7R334K50
C71 ~ C72 (C73 ~ C75)	3 (+2)	3.2 x 1.6 x 1.25	Ceramic capacitor 10 nF, 630 V	Murata GHM1530X7R103K630
R27 ~ R30	4	1.6 x 0.8 x 0.8	Resistor, 100Ω	
R33, R34	2	1.6 x 0.8 x 0.8	Resistor, 5.1 kΩ	
R35	1	1.6 x 0.8 x 0.8	Resistor, 1 kΩ	
R36	1		jumper wire	
TM1, TM2	2		Temperature sensor	Semitec NTC103KT1608-1P
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	

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	V_{CC}	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	35	temp1
9	V_{CC}	18	clock1-bar	27	com0	36	temp2

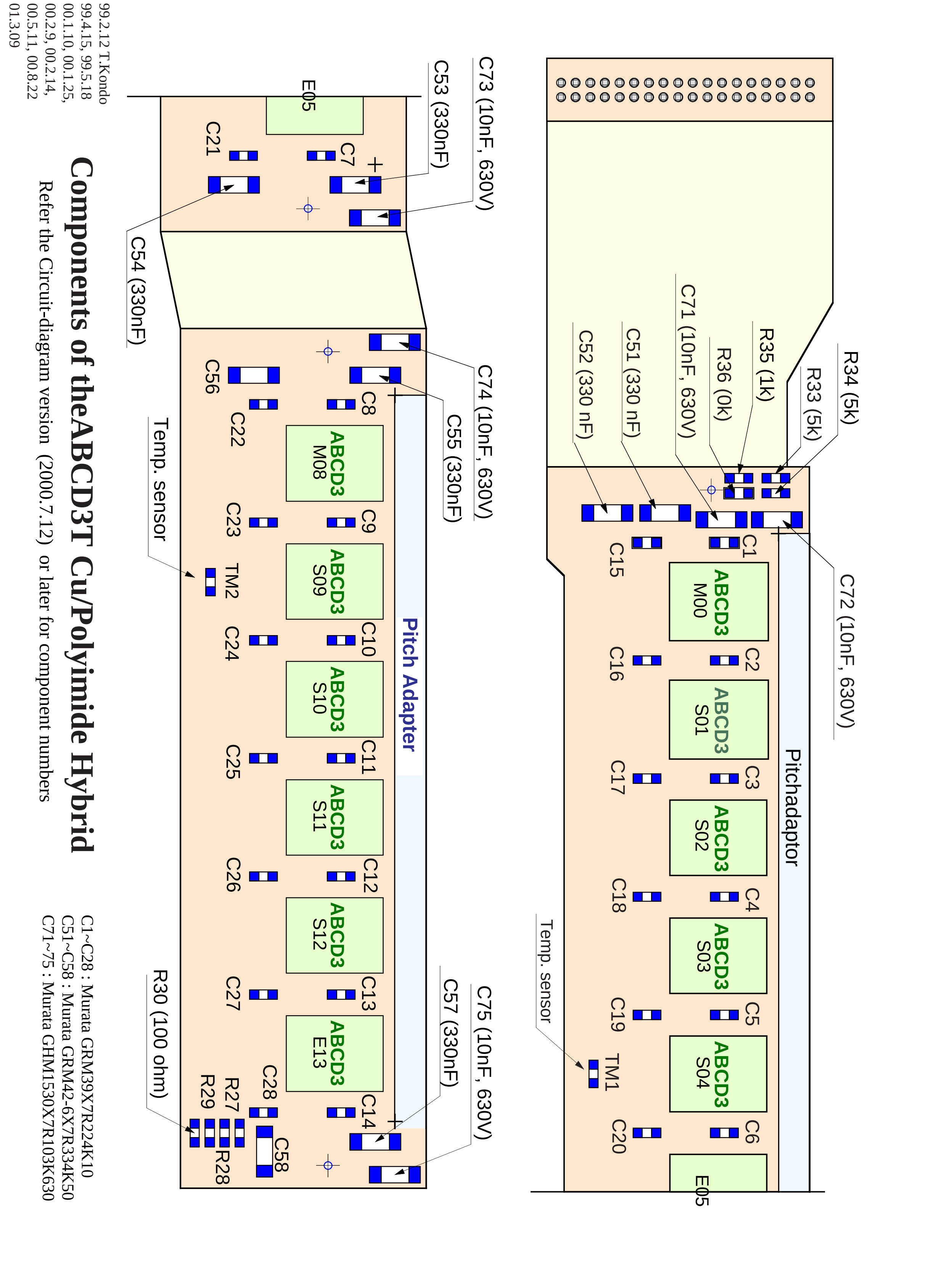

Figure 1: Component loading diagram of ABCD Cu/Polyimide hybrid (version 4)

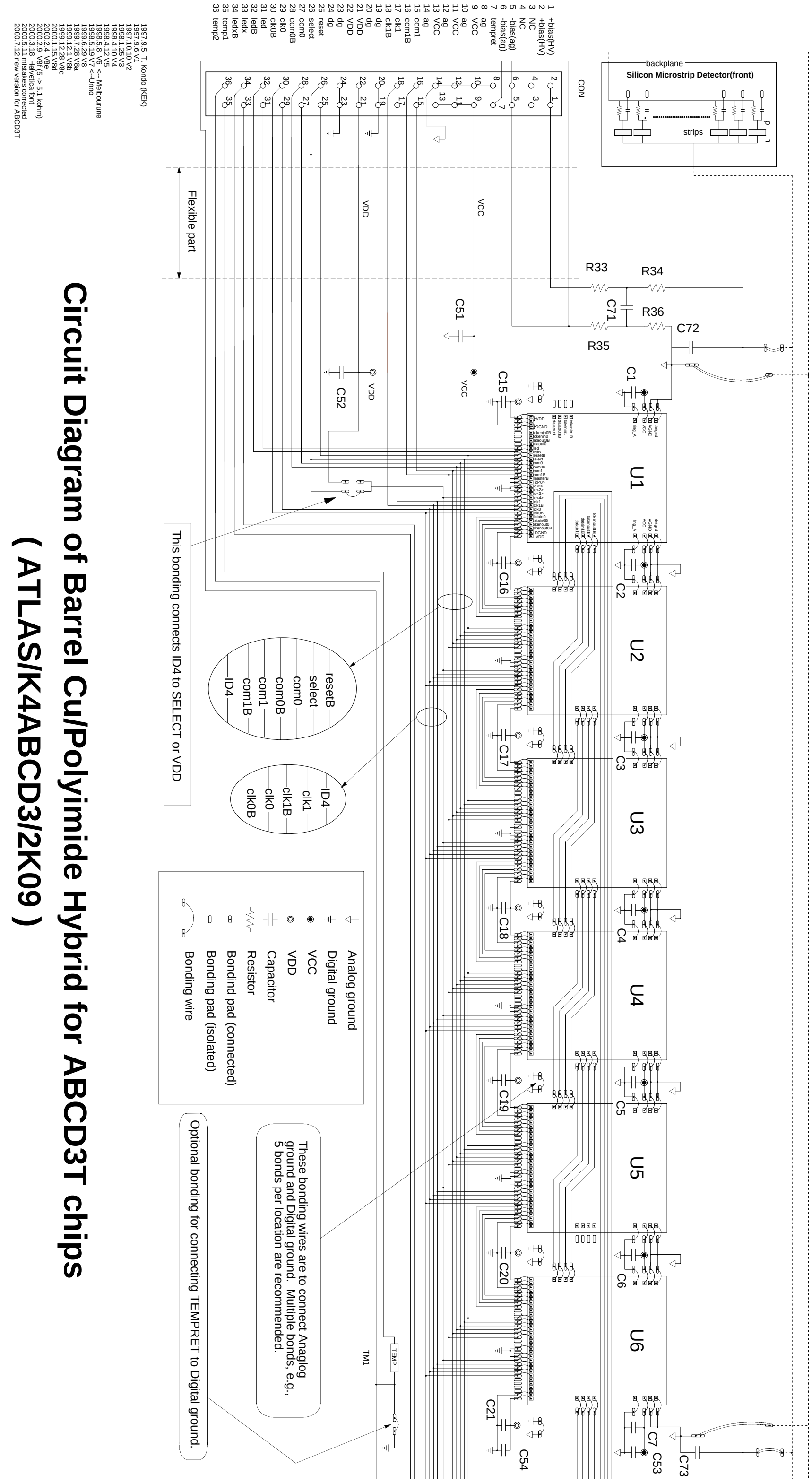

Figure 2: Circuit diagram of ABCD Cu/Polyimide hybrid (version 4), top-side hybrid

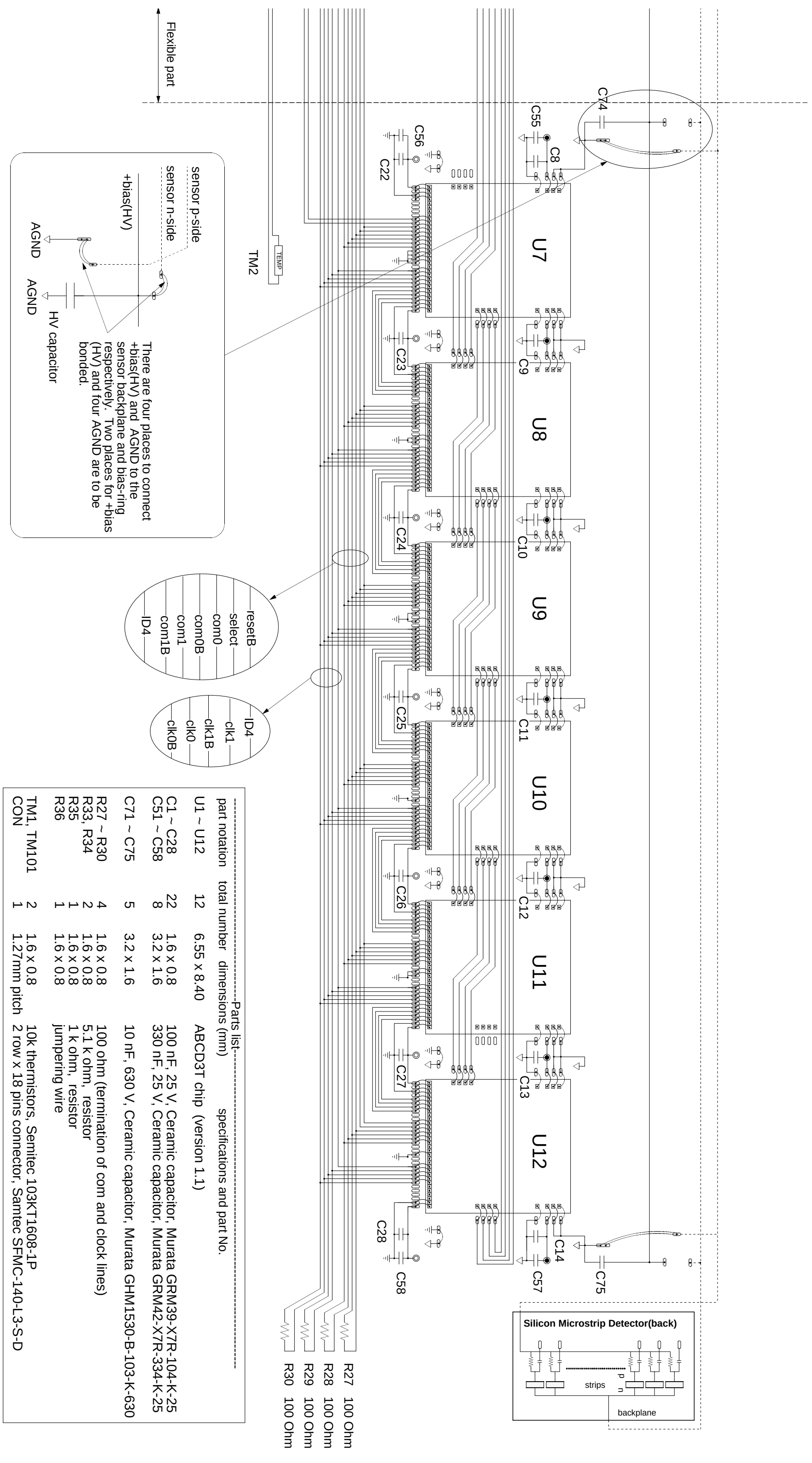

Figure 3: Circuit diagram of ABCD Cu/Polyimide hybrid (version 4), bottom-side hybrid

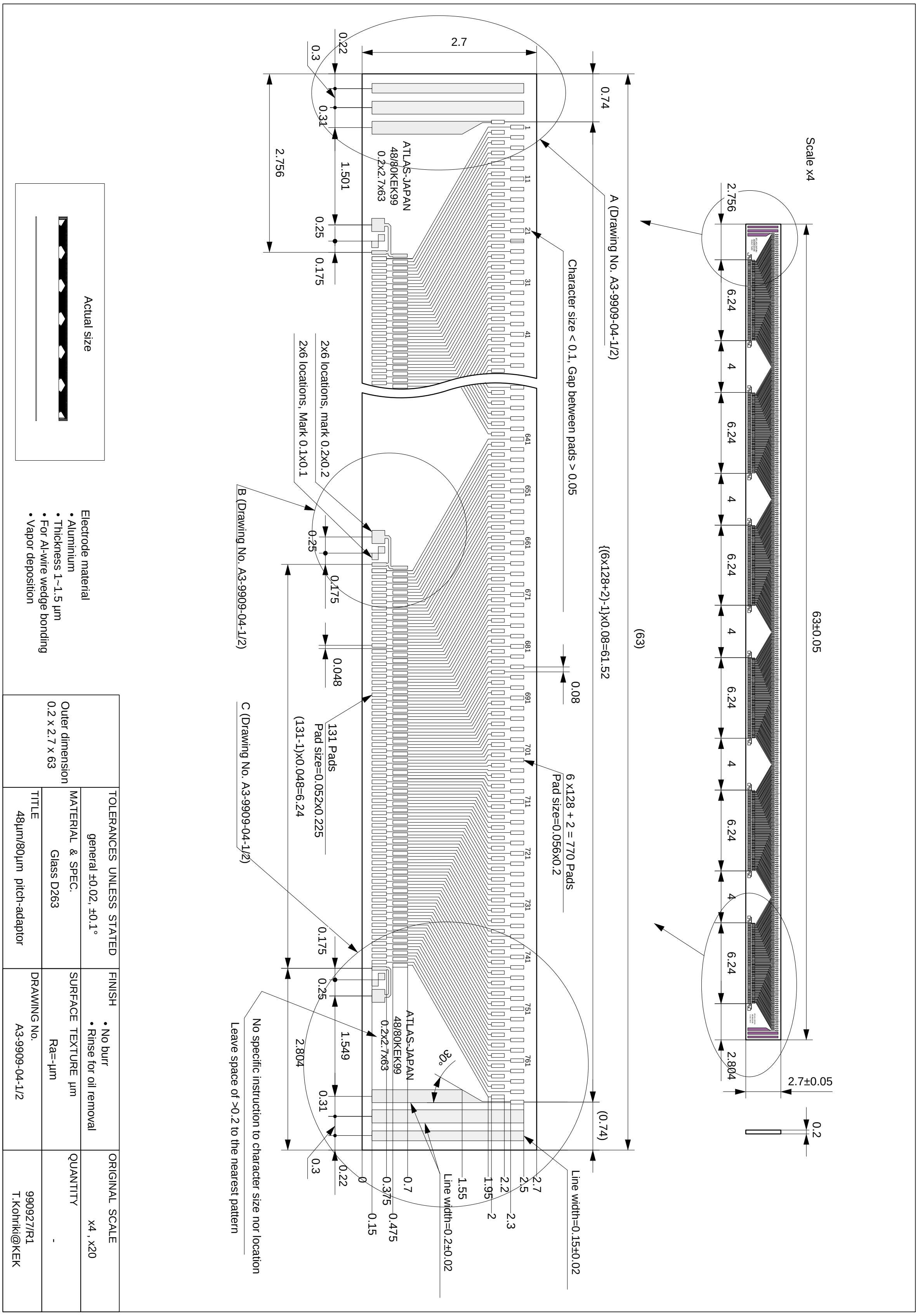

Figure 4: Glass pitch-adaptor of ABCD Cu/Polyimide hybrid

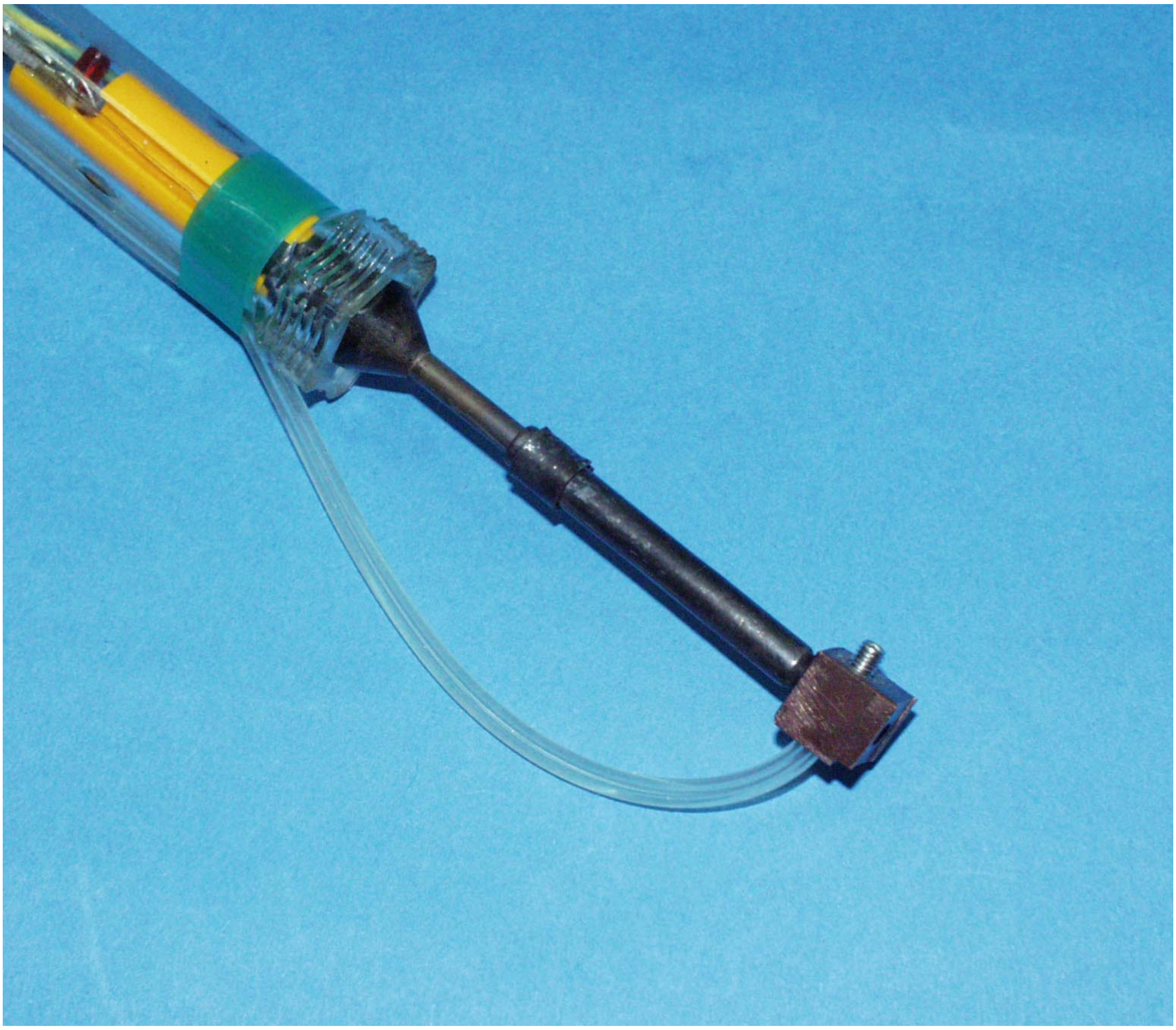

Figure 5: An IC heating and pick-up jig - Cu block on a soldering tip, with a vacuum line