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SCT BARREL MODULE Document

SCT Barrel Module: ASSEMBLY PROCEDURES & JIGS

Abstract

This document describes the barrel module assembly procedures and the jigs that are used..

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1. SCOPE OF THE DOCUMENT

This document describes the barrel module assembly jigs and procedures used by the four barrel clusters. It also describes a module transport and test box in Appendix 1.

2. MODULE ASSEMBLY STEPS

2.1 Overview

The barrel module assembly contains five specific operations. The manner in which these are carried out in the four assembly clusters in Japan, UK, Scandinavia and US has developed differently in some details, but each cluster is required to produce high quality modules that meet the same defined specifications. The encouraging achievements are presented and discussed in Sections 8 and 9, and documents are appended that discuss individual cluster procedures. In the initial step all the module component parts are inspected and their serial numbers checked against those in the construction database. Next the four silicon sensors have to be positioned precisely onto a baseboard to produce a detector-baseboard sandwich. A third step is attaching ASICs on the hybrids, and then in the module assembly the hybrids are mounted onto the detector-baseboard sandwich. Finally the ASIC inputs are connected to the individual sensor readout channels with wire bonds, and the sensor biasing connections are made.

2.2 Sensor-Baseboard Assembly

A great amount of effort has been put into developing procedures and jigs in this phase since the most demanding mechanical precision is required at this step. The elements involved are a pair of sensors on top and bottom of the baseboard. Requirements are to align each pair of sensors in the x-y plane, and also align the top and the bottom pair relative to each other and to the module reference point, the dowel holes. It is also important to minimise module distortion out of the x-y plane, i.e. in the z direction, and to prevent any mechanical damage to the sensors. All these are very demanding requirements.

2.2.1 Assembly station

The basic assembly procedure consists in having a station for aligning a pair of sensors, by using two sets of (x,y,Θ) stages, and large x and y stages to move the (x,y,Θ) stages under a microscope. One such arrangement of stages is shown in Figure 1. Some variations exist at the different clusters depending on the specific stages that are used.

A pair of aligned sensors are transferred to a pick-up jig with vacuum-chucking. Experimentally it was shown that optimised precision during the transfer process requires that the vacuum of the stages of the assembly station and the transfer jig are applied sequentially to avoid asymmetric forces on the aligned sensors. In order to confirm that the sensors have not moved beyond allowed tolerances, the transfer jigs have inspection holes at the fiducial marks through which co-ordinates are visually inspected before and after the transfer.

The surfaces of silicon sensors are protected at all stages, when in contact with jigs, by the use of clean-room paper that is renewed before each separate operation.

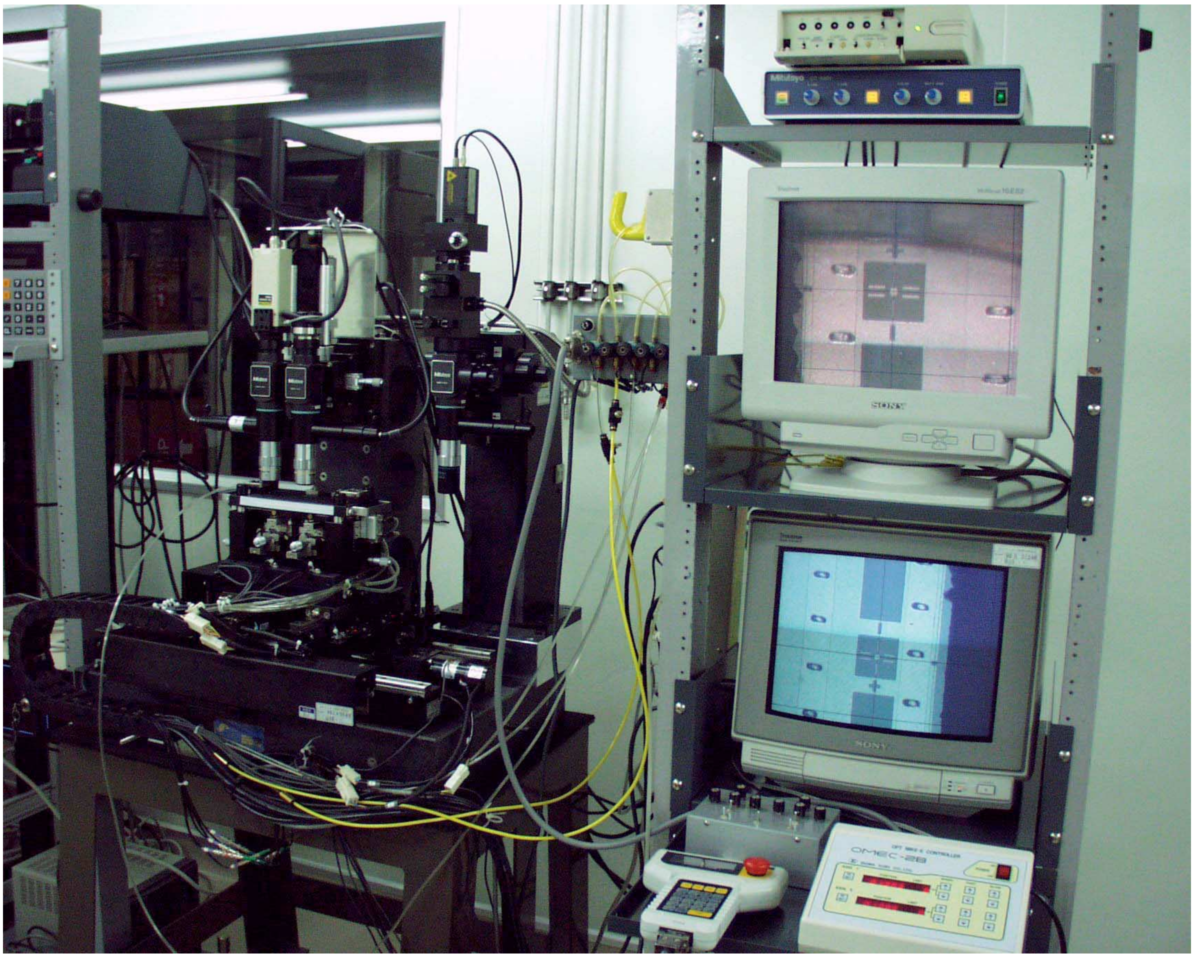

Figure 1   An example of assembly station

2.2.2 Gluing step and glue dispensing

In gluing the sensors to baseboards experience has shown that the preferred procedure is to hold the central baseboard area with a vacuum chuck and apply glue to the accessible surface and hence produce the completed sandwich assembly in a two-step process.

The detectors and the baseboard are glued with a room temperature curing epoxy glue, Araldite 2011, with a boron-nitride filler to improve the thermal conductivity[1]. A pre-defined amount of the epoxy glue is applied to the baseboard to ensure a specified glue thickness, and this is conveniently done using a dispensing machine which combines xyz stages with a glue dispensing unit. An example is shown in Figure 2.

There are two glue spots per sensor where electrical connection is made to the back-side with Eotite p-102, the same silver-loaded electrically conductive epoxy that is used for attaching the ASICs to the hybrid.

[1] M. Gibson, F.S. Morris, ATLAS Barrel and Forward Module Structural Epoxy Specification, http://hepunx.rl.ac.uk/atlasuk/sct/moduleAssembly/adhesivespec.pdf

Figure 2 Glue dispensing system which is made of (1) a xyz stage where the baseboard is on the xy stage and a glue-syringe is attached on the z-axis, and (2) a dispensing controller.

2.2.3 Documentation for the assembly sites

Details of the assembly station and assembly steps are described in the appended documents:

Appendix 2: Assembly jigs and procedures for the Japanese Cluster

Appendix 3: Assembly jigs and procedures for the UK-B and US Clusters

Appendix 4: Assembly jigs and procedures for the Scandinavian Cluster

3. ASIC ATTACHMENT AND BACK-END WIRE BONDING ON THE HYBRIDS

The hybrids for the barrel modules are to be delivered to the module assembly clusters with passive components surface-mounted, but without ASICs. Firstly, defined wire-bond pull-tests are carried out to ensure bondability before ASICs are attached and then fully bonded.

ASICs are glued on the chip pads with an electrically conductive epoxy, Eotite p-102[1] which has been chosen after showing successful electrical performance and suffering no adverse affects after irradiation in prototype modules. During the application of the adhesives and attaching the ASICs, care is taken to protect bonding pads from surface contamination. The adhesive is cured at a temperature at 50 ^{o}C for a period of greater than 2hrs.

After curing the ASIC adhesives, the back-end wire-bonding is carried out so that the ASICs electrical performance can be tested.

4. MOUNTING THE HYBRID

In the barrel module, the hybrid is wrapped around the sensor-baseboard assembly and this is most conveniently done with a customised tool. Details of this are given in the appended assembly documents, and positioning tolerances of ±50 µm in both the x and y directions are achieved

5. FULL WIRE-BONDING

Following the hybrid mounting and curing of adhesives, a set of electrical connections are made:

Firstly, individual connections are made to the supply bias and for the return current from the detectors. The electrical bias connection to the backside of the sensors is made through the conducting baseboard and the hybrid connections are wire-bonded to electrical connections on the upper-side beryllia facings which have been directly connected with conducting epoxy to the baseboard substrate. The ground return is wire-bonded from the bias ring on the strip side of the detector to a trace on the fan-in and then into the pre-amplifier ground contact.

Secondly, the high density wire-bonds are made from the ASIC to the fan-ins, and from the fan-ins to the sensor, and from the sensor to the sensor. There are in total 4608 of these bonds per module. This step uses a dedicated automatic wire-bonder. With 80µm pitch there is no problem bonding under fully automatic control. Particular care is, however, required to bond from the step down between fan-ins and sensors, which is about 1 mm. It is estimated that one complete module can be bonded and inspected within 4 hours during series production, dependent upon interleaving the necessary operations.

Full details of the wire-bonding scheme are provided in the document *ATLAS SCT Barrel module wire-bonding scheme*[2].

[1] Eotite p-102, http://atlas.kek.jp/~unno/SCTSGmod/glue/eotitep102.pdf

[2] T. Kohriki et al., http://atlas.kek.jp/~unno/SCTSGmod/mod00/Wirebondscheme.pdf

Appendix 1 Module Transport and Test Box

1 OVERVIEW AND REQUIREMENTS

A barrel module is a delicate device with well-defined mechanical, thermal and electrical properties. Its fabrication is described elsewhere in these FDR documents, and the present document addresses the box into which it is placed immediately after its construction. The module remains in this box until it is mounted on the barrel cylinder assembly, and during this potentially significant period of time the following operations are expected to be carried out:

(i) electrical testing [and thermal cycling where necessary] and storage

(ii) transport to the barrel module mounting site

(iii) storage and subsequent mounting on to a barrel cylinder

To be appropriate for these functions the box must include a basic module carrier, possess a cooling interface which is serviced internally by fluid flow, and have appropriate connections for the fluid and for attachment of an external inert gas supply. It has to be fitted with an integrated PCB and the appropriate electrical connectors. Whilst in the carrier the module must be protected at all stages by top and bottom cover plates. Various prototype boxes have been produced to meet these needs and shown to provide the necessary functions. However, further global requirements are needed for the final box, as in the module series production phase more than one thousand of these units will be needed. This requires the unit to be produced at an acceptable cost and in a process capable of medium scale production. Such a working example is given below to show that at least one solution already exists. The final box will be agreed shortly when all prototypes have been evaluated. Figure 1 shows an initial prototype box, and Figure 2 shows its latest design, where the engineering drawings are converted into a virtual solid model.

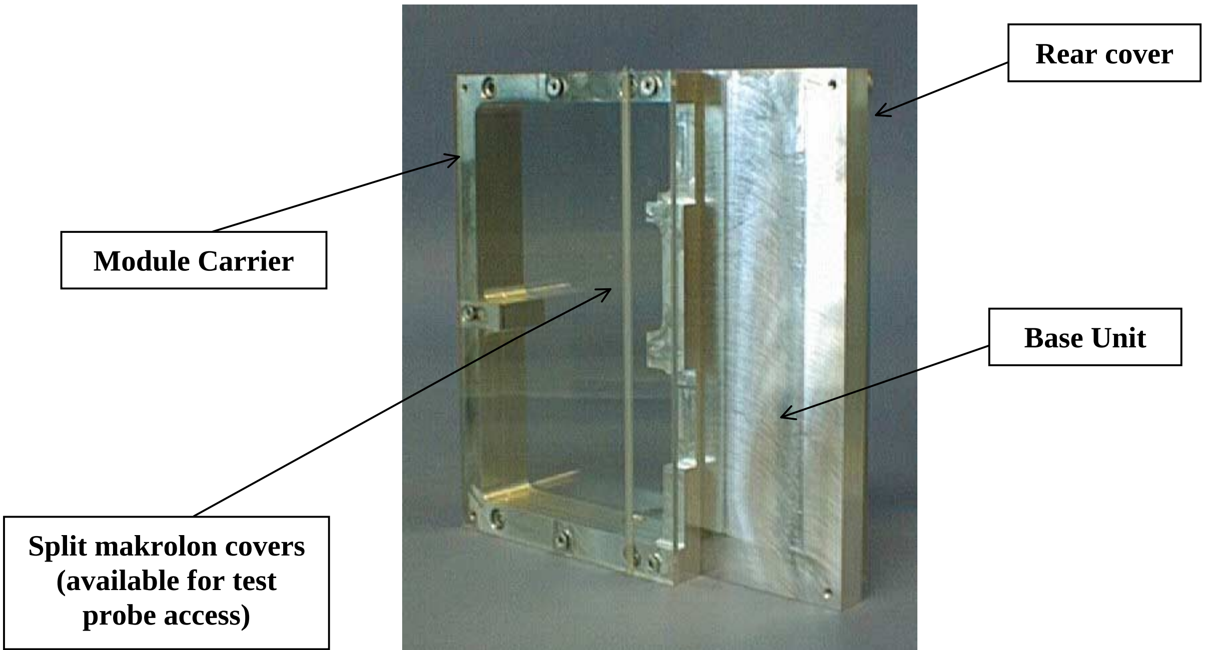

Figure 1. Initial prototype box

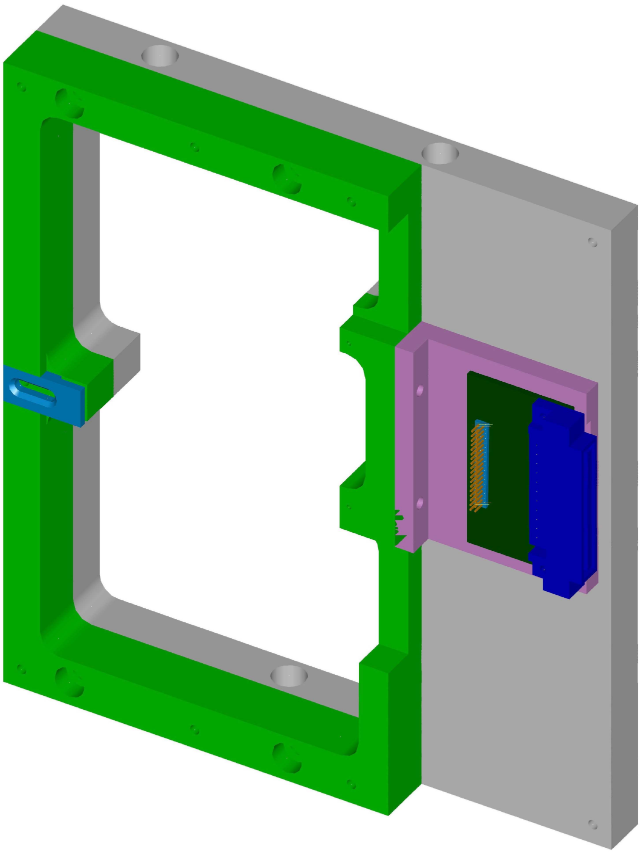

Figure 2. Virtual solid model of latest carrier and test box

2 COMPONENT ITEMS

(1) Module Carrier:

This is machined from cast aluminium tooling plate to a general tolerance of ±0.1mm, with the areas where the module is supported being machine to a higher precision of ±0.05mm. These regions also correspond to where the module-mounting robot requires direct access to attach to the module itself. The module is fixed to the carrier by two screws through the large cooling facings, and the far side of the module is restrained from moving out of the plane by a sliding clamp incorporated into the carrier frame. Oversize makrolon covers are attached to the front and back of the carrier to protecting the kapton electrical pigtail and its connector that emerge from the body of the module. The makrolon can be further strengthened at its two outer corners by the addition of two 15mm PCB-style spacers that hold the front and rear covers apart. An angled bracket fixed to the side of the framework allows the pigtail interface card and its components to be retained for each individual carrier. In total more than 1000 of these units could be needed.

(2) **Base Unit:**

This is machined from the same material as the carrier and to the same tolerances and aperture profile. There are four connections to the unit (two entries and two exits) two to allow coolant fluid to flow through the base unit and two to provide the inert gas environment for the active module. The fluid passes directly beneath the cooling-side facing, while the gas is distributed throughout the full volume of the box, with the pipe fittings being appropriate for connection to push-fit 6mm tubing. Each module-testing site will require a few of these, and the total number should be about 20 units.

3 BASIC OPERATIONS

- In storage and transport mode: the module is fitted within the carrier, and the large covers are in place, and inert gas supplied as required.

- In module test mode: the rear cover is removed and the module within its carrier is attached on to the base unit and electrical, fluid and gas connections are made. If test access is required the top cover can be removed and the carrier unit fitted with split test covers.

4 SUMMARY

By separating the carrier and module test functions it has been possible to reduce the number of components for this unit and hence reduce the overall system costs. In this way modules can undergo initial tests in a safe manner after their construction, be stored and transported safely, and have minimum handling through to mounting on the barrel cylinders, by allowing access for the mounting robot directly in to the box. Agreement on the final version of the box and its accessories will be made shortly, and production will start during summer 2001 and be completed by the end of 2001.