ATLAS Hybrid / Module program

Specifications & Criteria to be used in selecting the hybrid baseline technology

The hybrid/module program was agreed by the SCT institutes (SCT Institute Meeting 4/6/99). This document contains a draft specification and a proposal for the steps & criteria to be used in deciding the hybrid technology.

This draft has been produced by those leading the hybrid developments:

Tony Carter (Barrel TPG/Polyimide/Thin film Aluminium)
Carl Haber (Barrel BeO/Au or Ag)
Nobu Unno (Barrel Kapton with ?? substrate)

Neil Jackson (Forward BeO/Au)
Jens Ludwig (Forward Kapton with ?? substrate)

and the steering group.

Specifications to be circulated separately by Carl Haber & to include :

- Mechanical :
  - Dimensions
  - Stability (temperature, time)
  - Thermal performance
    - Max temp. with 7w
    - Change in dimensions from –30 °C to +100 °C [1]
  - Radiation tolerance
- Electrical:
  - Electrical schematic
  - Electrical interface to dog-leg
  - Allowed resistances, capacitances, inductances of printed circuitry
  - Variation of electrical characteristics with temperature
  - Quality of the connections to surface mount components
  - Quality of the wire-bond connections
  - Grounding, screening
  - Tolerance to radiation
  - Electrical performance
    - S, N
    - Occupancy vs threshold
    - Stability
    - ………….

[1] The range of temperatures which a hybrid/module could experience is (-25°C - +70°C). The low temperature could occur with an un-powered but cooled hybrid; the high temperature could occur with
a powered un-cooled hybrid.

For demonstrating the reliability of a technology hybrids need to be measured and cycled over the range (-25°C - +100°C).

Criteria to be used in selecting the hybrid baseline technology:

Because of the delay in producing the FE ASICs the choice of the hybrid technology will proceed in two stages. In the first stage all properties of the candidate hybrid technologies except for the electrical performance are to be shown. Only those options, which are shown to have the required mechanical and thermal properties will be carried forward to the second stage and equipped with readout ASICs and evaluated

The Stage-1 program is arranged to obtain the required information as economically as possible – minimising the number of hybrids needed and working together to provide standard components and to make use of existing test equipment. As many of the measurements are complicated and need to be carried out under standard conditions, all measurements should be checked. Measurements should be made at the site where the modules are fabricated and checked at another site. (RAL is prepared to help with checking these measurements if requested.).

For the Stage-2 program of electrical measurements, it is proposed that all barrel (forward) modules should be built and have first measurements done at a common barrel (forward) production site(s). These production sites should have the capability of building & testing 6 modules in a period of 2 weeks. More detailed measurements could then be carried out at the separate institutes. Finally the modules would be brought together at CERN for comparative measurements in the system test lab and the testbeam.

The decision process will be as follows:

- In the September SCT meeting, a decision will be made on which options satisfy the mechanical and thermal requirements.
- In the December review, an attempt will be made to rank the options using the technical quality as a criterion.
  - If this ordering can be agreed, then choose the highest quality which is affordable
  - If this ordering cannot be agreed then, choose the lowest material option unless a majority of the cluster representatives decide that :
    - the reliability has not been satisfactorily demonstrated OR
    - the complexity of the assembly is unacceptably high OR
    - the cost is un-affordable.
- To make the recommendations to the Institute board, 2 internal review committees will be formed – 1 for the barrel and 1 for the forward. Each committee will be consist of 1 representative/cluster (Japan, Nordic, US and UK for the barrel; CE, CS and UKV for the forward) plus the technical co-ordinator, the project leader.

Stage-1 Mechanical and thermal properties of the hybrid to be demonstrated by Sep. 99 :

A series of measurements are proposed, to be made both before and after thermal cycling using " engineering hybrids and modules". In all cases at least 2 samples are to be measured and checked at a second site. The following pieces will be needed:

1. 2 'engineering' hybrid sets equipped with heaters and PT1000s for measurements of hybrid properties before & after thermal cycling. A hybrid-set is a fully integrated object with fan-ins, pigtails, interconnects and substrates

2. 4 'reject' hybrids for destructive tests (2 before thermal cycling; 2 after). For the barrel these can be single or half hybrids

3. 2 'engineering' modules ie 'engineering' hybrid sets equipped with heaters and PT1000s made up into modules with realistic baseboards/spines and dummy silicon. For measurements of module properties before & after thermal cycling

The hybrids incl. fanins, pigtails… will be provided by the proponents. However it would be useful to keep all other components common. For each option the following are required :

- Heater packs (4hybridsx12 = 48/option)
- PT1000 (4hybridsx8? = 32/option)
- Baseboards (2/option)
- Dummy detectors (2x4/option)

1. Estimation of radiation length

A detailed description of the hybrid and module to be supplied with spreadsheet containing sufficient details (substrate, glues, printed circuit, connectors) to allow the radiation length and weight to be calculated (the weight can easily be compared with measurement).

To be co-ordinated by:

2. Hybrid thermal performance.

The aim is to understand the thermal properties of a hybrid by measuring the temperature at a few points on a hybrid heated as describe above.

The forward hybrids should be mounted and cooled with the cooling block at 10^{o} and with an ambient temperature of 22^{o}, and avoiding draughts.

Two possibilities exist for the barrel hybrids :
1)A half-hybrid to be mounted and cooled on one edge with the cooling block at 10^{o} and with an ambient temperature of 22^{o}, and avoiding draughts
2)A hybrid pair to be mounted on a baseboard and cooled on one edge with the cooling block at 10^{o} and with an ambient temperature of 22^{o}, and avoiding draughts. The same information could be obtained from the engineering module

To be co-ordinated by:

3. **Hybrid thermal distortions**.

The aim is to understand the stresses induced in the module by measuring hybrid distortions. Ideally the temperature should be varied from –30 to +100 but this will depend on the practicalities of doing the measurement.

The forward hybrid should be mounted on the normal mounting point and the surface profile measured at several temperatures.

A barrel half-hybrid should be mounted on the normal cooling point and the surface profile measured at several temperatures. This should be repeated with the hybrid fastened at both edges constrained, to measure any bow or other distortion.

To be co-ordinated by:

4. **Hybrid mechanical distortions**.

The aim is to understand the stresses induced in the module by measuring hybrid distortions.

The distortion of the hybrid as defined in 3. is to be measured by loading the point furthest from the mounting block and comparing measurements loaded and unloaded at room temperature (22 ^{o}).

To be co-ordinated by:

5. Hybrid peel tests

The aim is to measure the peel strength of to measure the adhesion of the Kapton & thin-film & interconnect to the substrates.

This is a destructive test and needs to be carried out using ‘reject’ pieces. Standard methods exist and need to be adapted to our situation. (e.g. IPC-TM650). A force to applied upto 0.7Kg/cm (to be agreed)

To be co-ordinated by:

6. Quality of the bond-pads.

A sample of 20 bonds to be made under standard conditions (hybrids stored under nitrogen?, plasma etched before bonding?….) and then measured with a pull-tester (>7g?).

To be co-ordinated by:

7. **Electrical integrity of the printed circuit**.

All traces should be checked from input at the connector(s) to the output at the ASIC bonding pads for continuity. In addition the resistivity , capacitance(?) and inductance(?) of traces to be measured. The bias lines to be held at 500volts for 24hours with leakage current monitored.

Tests to be defined and work co-ordinated by:

8. Quality of the solder or electrical glue joints

Tests are to be carried out, as described by Carl Haber, to check the mechanical quality of the electrical connections. Copper wires are to be connected to a sample of pads and a pull-test performed to measure the force required to cause a failure (>227gm?). An alternative (‘the sticky tape test’ to be considered for thin-film and bond pads

Tests to be defined and work co-ordinated by:

9. Resistance of 'wrap-around' to mechanical damage

The barrel wrap-around, the forward hybrid to be subject to 5 cycles of bending with a radius of 1mm Measurements to check made for open circuits

Tests to be defined and work co-ordinated by:

Thermal, Mechanical & Electrical integrity.

The above measurements on the hybrids should be completed and checked at a second site.

The thermal, mechanical and electrical integrity of the hybrid is then to be tested by thermally cycling the hybrid from (-30^{o}) to ($+100^{o}$) in an environmental chamber. A total of 10cycles should be carried out following a sequence as defined by Carl Haber.

Tests 2-9 should then be repeated

Engineering Module thermal performance

An engineering module is defined as a module built of dummy silicon wafers, a final baseboard (TPG, Ceramics) and an engineering hybrid as defined above. The detector assemblies and preferably the whole modules should be built at the same site to ensure that the same glues and glue thicknesses are used. The module will be be mounted and cooled in the correct final configuration.

The modules should be cooled to $+ 10^{o}$ with the ambient temperature of 22^{o}, but avoiding any draughts. The temperature on each of the chips should be measured with a non-contact device.

12. Engineering module thermal performance.

The aim is to understand the thermal properties of a module by measuring the temperature at a few points on the hybrid heated as describe above.

The modules should be mounted and cooled with the cooling block at 10^{o} and with an ambient temperature of 22^{o}, and avoiding draughts.

To be co-ordinated by:

13. Engineering module thermal distortions.

The aim of these measurements is to measure the mechanical distortions of the modules made up with the different hybrid options.. Ideally the temperature should be varied from –30 to +100 but this will depend on the practicalities of doing the measurement.

The module shoul be mounted on the normal mounting point and the surface profile measured at several temperatures.

To be co-ordinated by:

Thermal, Mechanical & Electrical integrity.

The thermal & mechanical integrity of the module is to be tested by thermally cycling the module from (-30 ^{o}) to (+100 ^{o}) in an environmental chamber. A total of 10cycles should be carried out following a sequence as defined by Carl Haber.

Tests 12-13 should then be repeated

Stage-2 Electrical performance with a final review in Dec. 99:

At least two fully loaded modules of each type to be considered should have been built and evaluated. All barrel modules should be built at a common location. All forward modules should be built at one location. Performance measurements should be carried out collectively and verified in the system test and/or beam test at CERN.

The following are expected to be presented:

1. Summary of the earlier thermal/mechanical measurements

2. Electrical performance

3. Report from the forward & barrel module teams on the build process
   - Document steps in the hybrid assembly
   - Document steps in module assembly
   - Wirebonding

   Items to be covered to include the time needed, difficulties encountered….)

4. Radiation tolerance

   i.e. a summary of what has been irradiated

5. Cost (to be supported by industry offers)