Assembly Procedures for Barrel Modules and Sextants

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I Overview of Assembly Procedures

This section will give an overview of the assembly procedures for the barrel modules and sextants. Each module is assembled from two Detector-Fanout Assemblies (DFA), two hybrids (HDI) and a Kevlar support structure. The sextants are formed by attaching a Layer 1 module to a Layer 2 module.

The DFAs will be assembled and tested in Pisa before being shipped to Santa Barbara where the module assembly will take place. Similarly, the HDIs will be assembled and tested in Milan before being shipped to Santa Barbara. The Kevlar support structures will be assembled in Santa Barbara. Once the DFAs arrive in Santa Barbara, the wirebonding of the silicon strips to the Upilex fanout will be done. Then the HDIs will be glued to the fanouts, and the fanout traces will be wirebonded to the front-end ICs. Two completed HDI/DFA assemblies (HDFA) will then be connected together with the Kevlar supports to form a module. Throughout the assembly process, tests will be performed to assure the quality of each step. Finally, the completed modules and sextants will be shipped to LBNL for final assembly of the SVT.

II DFA Wirebonding

II-A Receiving

Once the DFAs arrive in Santa Barbara, they will be visually inspected, surveyed and logged into a database. The inspection will be looking for any possible damage which may have occurred during shipping. The optical survey will be done to provide a redundant check of the position of various features on the silicon wafers and fanouts with respect to each other (these things will have already been measured in Pisa). The total thickness and flatness of the DFA will also be measured. This survey will be done using a microscope and coordinate measuring table that has a accuracy of a few microns. Then the DFA will be inventoried. The results of these measurements and all previous tests and measurements on this DFA will be stored in a database. The history of the DFA will be continuously logged throughout the assembly process to help assure that no damage has occurred.

II-B Ring Frame

After the DFA has been received, it will be transferred into a fixture referred to as a "ring frame". By holding the DFA around it's perimeter, the ring frame allows both sides of the DFA to be accessed without any direct handling of the silicon. Wirebonding, testing and attachment to the HDI will all be done without having to remove the DFA from the ring frame. The DFA will remain in the ring frame until it is ready to be paired with another DFA and assembled into a module. This makes the handling of the silicon as minimal as possible, thus reducing the risk of damage.

The ring frame needs to hold the DFA for wirebonding, and be able to accommodate both the Upilex testing tree (which will be used for testing the silicon before the HDI is attached), and the HDI. Drawings of the ring frame with the Upilex testing tree and with the HDI are shown in Figures 1 and 2, respectively.

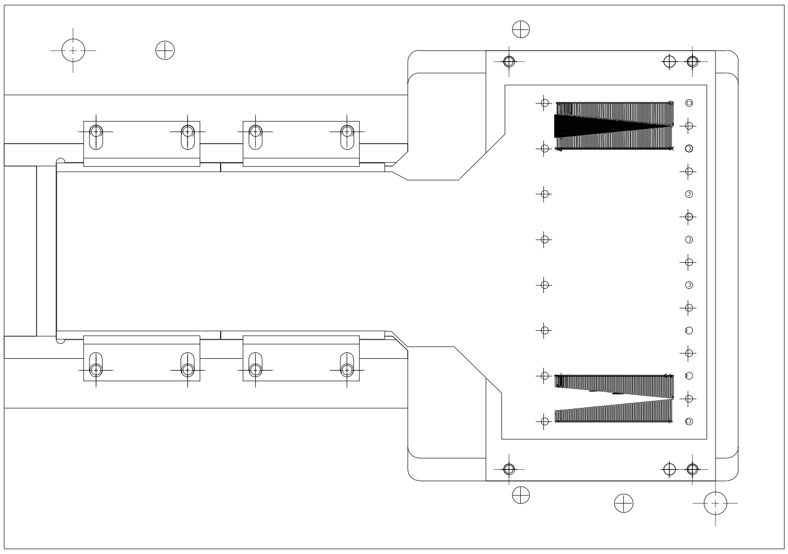

Figure 1: Ring frame and DFA with Upilex testing tree still attached

The ring frame will be made of 0.290" thick aluminum. Is needs to be kept thin to allow for clearance of the automatic wirebonding machine. The DFA will sit on a ledge in the ring frame 0.040" wide which surrounds three sides of the DFA's perimeter (the side nearest the HDI will not be sitting on a ledge). The ledge will be made of Teflon glued to the aluminum frame. The DFA will be held in the ledge with Teflon clamps. Thus, the only material to contact the silicon surface while it is in the ring frame will be Teflon.

When the Upilex testing tree is still on the fanout, it will be supported in the ring frame by a removable G-10 backing plate. To keep the location of testing tree well aligned to the testing probe, the G-10 plate will have alignment pins which match holes in the testing tree. Once the testing tree is cut from the fanout, the HDI will get mounted on a bridge and positioned in the ring frame, as shown in Figure 2.

The ring frame will be equipped with lucite covers which will be used to protect the detector and wirebonds during handling and storage.

II-C Wire Bonding and Testing

After the DFA is transferred to the ring frame, the wirebonds can be made. The sequence of bonding and testing will be:

- Wirebond ϕ-side bias line
- Wirebond z-side bias line
- ○ Test, Leakage Current vs. Bias Voltage

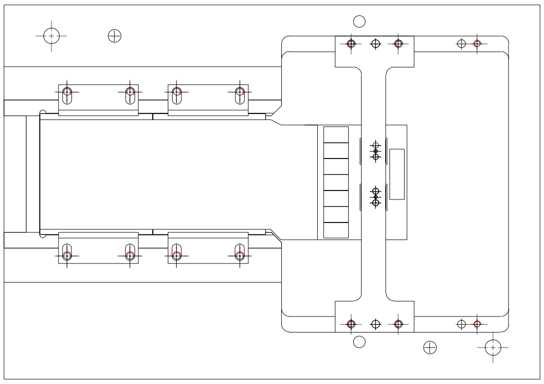

Figure 2: Ring frame and DFA with HDI attached

- Wirebond ϕ-side Silicon-to-Fanout bonds, Inner Row
- ◦ Test, $I_{Leak} vs. V_{Bias}$, Shorts, Broken Capacitors
- Wirebond ϕ-side Silicon-to-Fanout bonds, Outer Row
- ◦ Test, $I_{Leak} vs. V_{Bias}$, Shorts, Broken Capacitors
- Wirebond ϕ-side Head-to-Head bonds, Inner Row
- ◦ Test, $I_{Leak} vs. V_{Bias}$, Shorts, Broken Capacitors
- Wirebond ϕ-side Head-to-Head bonds, Outer Row
- ◦ Test, $I_{Leak} vs. V_{Bias}$, Shorts, Broken Capacitors
- Wirebond z-side Silicon-to-Fanout bonds
- ◦ Test, $I_{Leak} vs. V_{Bias}$, Shorts, Broken Capacitors
- ◦ Test, Scan with IR LED

All of the tests are done using a probe card that contacts the Upilex testing tree. Details of the testing are described elsewhere (???).

When the ϕ-side is being bonded, a support bar will be placed under the DFA directly below the wirebond area to keep the DFA from flexing under the pressure of the wirebonder. The bonds on the ϕ-side are done in two rows: a first row of short, low bonds with a second row of longer, higher bonds over the top of the first row. This is done because the bonding pitch on the ϕ-side is small enough to require the bond pads to be staggered. A testing sequence will be done between rows since it is easier to fix shorted wirebonds in the first row before the second row is done.

II-D Storage

After the wirebonding is finished on the DFA, it will be stored (still in the ring frame) in a humidity and temperature controlled cabinet. We will have the ability to bias the silicon and monitor leakage current.

III HDI Receiving and Testing

The following sequence of operations will be performed on the HDIs when they arrive in Santa Barbara:

- Inventory
- Optical Inspection and Survey
- Transfer to HDI Testing Fixture
- Electrical Test of HDI
- Glue Bushing to HDI

After each HDI has been inspected, a complete electrical test using the DAQ test stand (describe in a later section) will be performed. This test will have already been performed on the HDI before it was shipped. Once it has been determined that the HDI is functioning properly, the brass bushing will be glued to it. The bushing is used to fasten the HDI to the cooling rings in the final assembly, and provide a temporary connection between the HDI and the Kevlar support structure during certain stages of the module assembly.

A special fixture will be required for handling the HDI, since it is double sided with exposed components and wirebonds on both sides. It is in this fixture that the HDI will be tested and stored until it is time to attach it to a DFA.

IV Connect HDI to DFA

After the DFA is wirebonded and the HDI is tested, they are ready to be attached to each other to form a Hybrid-Detector-Fanout Assembly (HDFA). The assembly sequence is:

- Remove Upilex Testing Tree, Both ϕ and z Sides
- Position HDI in Ring Frame
- Glue ϕ Fanout to HDI

- Glue z Fanout to HDI
- Wirebond Bias Lines, Both Sides
- Electrical Test
- Wirebond ϕ Side Fanout to HDI, Inner Row
- Electrical Test
- Wirebond ϕ Side Fanout to HDI, Outer Row
- Electrical Test
- Wirebond z Side Fanout to HDI, Inner Row
- Electrical Test
- Wirebond z Side Fanout to HDI, Outer Row
- Electrical Test
- Burn-In / Storage

IV-A Removing Upilex Testing Tree

Before the HDI can be glued to the fanout, the testing extension on the Upilex must be removed. This can be a rather delicate operation since traces on the Upilex are very fine and at small pitch ($\approx 50\,\mu$m). One must be careful not to break or short any of the traces during the cutting operation. We have had success cutting the fanouts with a surgical scalpel, replacing the blade after every few cuts. We are also developing a small rotary cutter that would not drag across the traces as a knife does, possibly reducing the chance of damage.

IV-B Placing the HDI in Ring Frame

Once the Upilex extension has been successfully cut from the DFA, the G-10 backing plate will be removed from the ring frame. The HDI will be mounted to a bridge with screws through the brass bushing. The bridge will then be positioned into the ring frame.

IV-C Gluing Fanouts to HDI

The fanouts are glued to the HDI on a 5 mm contact area just in front of the ICs. When gluing the fanouts to the HDI, one must assure that the area under the bond pads on the fanout is completely covered with glue and that no glue runs out on to bond pads on the HDI. Successful wirebonding requires that the bond pads on the fanout have a solid foundation, and that the bond pads on both the fanout and HDI remain clean.

First, the fanout will be lifted slightly above the HDI to make room for the glue applicator. If need be, the fanout will be stress relieved at the glue joint to the silicon wafer to prevent any forces from being placed on that joint. The epoxy will be applied to the HDI either by hand or with a glue dispenser. Both techniques are currently being evaluated. Once the glue has been applied, the fanout will be released and clamped into place with a Teflon clamp while the epoxy cures. The same technique will be used for both the ϕ and z sides.

IV-D Wirebonding and Testing

The wirebonds to the bias lines on both sides of the HDFA will be the first things done after the fanout gluing is complete. The $I_{Leakage} vs. V_{Bias}$ characteristics will then be remeasured. The wirebonding will continue with the bonds between the fanout and the front-end ICs. The bond pad pitch is $45\,\mu$m, necessitating staggered pads and hence an inner and outer row of bonds. After each row of bonds is completed, an electrical test will be performed.

IV-E Burn-In and Storage

Once all of the wirebonds have been completed, the HDFA will be placed in a humidity and temperature controlled cabinet with all standard operating voltages applied (bias voltage and HDI supply voltages) for a burn-in period of one month, minimum. During this time, leakage current and all operating conditions will be continuously logged by computer into a database. After the burn-in period, the full set of electrical tests will be repeated.

V Support Structure Assembly

The Kevlar-epoxy composite support structures are manufactured from a laminate consisting of four layers of Kevlar 29 cloth and a heat resistant laminating epoxy (Ciba-Geigy RP4005R/RP1500H). The laminates are molded under pressure, resulting in a material with total thickness of 0.41 mm.

The molded Kevlar is then laser cut into the shape of the final part. Drawings are the ribs and end-pieces where shown in Figures **??** to **??**. For Layer 1, there are no end-pieces, just two ribs. For Layers 2 and 3, the two ribs are glued to the two end-pieces before being attached to the silicon. The ribs and end-pieces have locating holes cut in them which are used to control alignment. The support structure gluing fixture will have 8 pins, 4 for each end-piece, which are used in conjunction with the locating holes, to hold the ribs and end-pieces in place during the gluing procedure. This same fixture will then be used to position the support structure on the two HDFAs in the next assembly step.

VI Connect HDFAs to Support Structure

VI–1 Modules

The module assembly begins by removing the HDFAs from the ring frame with a transfer/alignment fixture. This is the first time in the assembly process that the HDFA is removed from the ring frame since arrival in Santa Barbara. The transfer fixture makes a vacuum contact to the z-side of the HDFA and lifts it out of the ring frame. Then this fixture is placed on a platen where it is aligned with respect to features on the platen. A second HDFA is then placed and aligned on the same platen in a similar way.

Glue is applied to the support structure, which is still in it's gluing fixture (or, in the case of Layer 1 where there is no gluing fixture, a fixture that just holds the ribs). The support structure gluing fixture is lowered on to the platen and held at a predetermined height to allow the glue to contact the two HDFAs. The posts and bearings used to mate the platen and the support structure gluing fixture keep the alignment of the two planes to within 10 μm.

The glue cures at room temperature, and then, for Layers 2 and 3, the HDIs are temporarily screwed to the end pieces. The modules will then be tested, and the sextants can be assembled.

VI–2 Sextants

For sextant assembly, the Layer 1 module will remain on the platen used for module assembly, and the fixture holding the Layer 1 ribs will be released and removed. The Layer 2 module will be lifted off it's platen by the support structure gluing fixture. The alignment of the modules in the fixtures is done so that when the Layer 2 module is lowered on the Layer 1 module's platen, it is already in the proper position. Epoxy will be applied to the Layer 1 module ribs, and the Layer 2 module will then be lowered into position.

After the glue has cured, the Layer 1 HDIs will get glued to the Layer 2 HDIs. This completes the sextant assembly. The sextant will then be retested and stored.

VII Final Survey

Before the modules and sextants get shipped to LBNL for assembly on the support cones, they will undergo an extensive optical survey. Fiducials on the silicon wafers and support structures will be measured to within 3 μm with respect to each other.