The improved ladder production for the Belle Silicon Vertex Detector (SVD2.1)

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After the upgrade of the Silicon Vertex Detector (SVD2) in Belle at the KEKB energy-assymmetric e+e- collider data taking resumed in autumn 2003. Although the upgrade was sucessful and SVD2 is working as expected it was decided to produce spare ladders for layer 1 and 2, which are the closest to the beam pipe and receive the highest radiation dose.

Each ladder is subdivided into two half ladders, each of which containing 1 or 2 double-sided silicon detectors (DSSD's). Flex circuits connect the DSSD's to the front-end readout electronics which consists of two back-to-back glued hybrid boards on which the readout chips are mounted. The overall structure is assembled on a support rib and 2 bridge pieces that align the DSSD's to the supportive end ring structure of the SVD.

While the overall design didn't change in order to produce compatible ladders for SVD2, in the spare production some significant improvements were achieved in the details.

For the SVD2 the hybrid boards were originally produced out of aluminum nitrite (AlN) which is rather expensive and turned out to be hard to work with. With the chosen design which includes a keyhole for mounting purposes, the boards are rather fragile and break easily when handled. The soldering of the surface mount components was quite difficult and repairs for the components with multiple legs almost impossible. As the thermal conductivity of the AlN is very high, the attempts to repair single legs with a solder iron failed and repairs were performed finally using a silver epoxy.

AlN was chosen originally because of the need to distribute the heat from the front-end readout electronics (VA1TA chips by IDEAS in Oslo, Norway) to the heat sink in the end-ring structure of the SVD detector. The new hybrid board is an FR4 board which required the redesign of the heat sink scheme of the ladder. For that purpose the 6-layer board is penetrated by a huge number of through holes under the VA1TA chips area filled with copper which guides the heat into a sheet of TPG (thermal pyrolytic graphite) which is located between the two hybrid boards. This material reaches a thermal conductivity of more than 1350 W/(mK). For comparison: the termal conductivity of copper is around 390 W/(mK), the one of AlN somewhere around 280 W/(mK).

Another issue for SVD2 was the production of the flex circuits. It was implemented on a single layer which required a strip pitch of about 50 micrometer over a length of 300 mm on the r-z flexes. This turned out to be possible, but technically very hard to realize and therefore time and cost intensive. The flex circuit was replaced by a 2 layer design reducing the costs significantly and improving the quality of the production.

The softness of the flex circuit causes problems during the bonding procedure and systematic studies were performed in order to ensure reproducible high quality bonding. Various heads for the wire bonding machine were tested and the form of the head plays a crucial role for the successful wire bonding. Another essential tool was a UV cleaner which was used on the various components prior to the wire bonding to get rid of any remaining organic traces on the bonding pads. To supply a good and reproducible substrate under the bonding pads various techniques of gluing the flex circuits to the DSSD's were explored and a silicon adhesive was chosen which comes on a tape and can be easily and very accurately applied to the components.

To ensure the quality of the ladder production a test setup was assembled in order to test the front-end readout chips at every stage of the production. A database with all test results was connected to a WEB interface which was developed in order to allow easy access to the test data.

The production and testing of the new ladder production will be finished in summer 2004 and will provide Belle with spare ladders for layer 1 and 2 for the SVD2. In addition valuable expertise was collected which will turn out to be useful for possible future projects such as e.g. a silicon detector for a high luminosity B-factory.