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State of the art technologies for front-end hybrids

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The front-end hybrids for solid state and gas detectors will be crucial components of the next generation detectors. Requirements such as high-density and high-speed interconnects, low mass, radiation resistance and high-current and high-power dissipation capabilities are examples of the challenges to be solved concurrently.
Over the past ten years we have been working on these problems for a variety of projects.

The technologies for front-end hybrids developed at CERN are presented and future possibilities such as embedding active and passive circuits are described. Comments are made concerning the ability to access these technologies for large scale production by industry.

Summary

The front-end hybrids for solid state and gas detectors will be crucial components of the next generation detectors. There are many different technologies that can be used to make those circuits that interconnect the different components.
Unfortunately low cost conventional PCB technology shows rapidly its limitations when high pin count components, high density connectors or chips without packages are used.

Other technologies such as HDI, MCM/D and MCM/C can increase the density but also have their weak points. Another way to increase the density without impacting too much the costs is to split the boards and to keep the high density only there where it is needed, for example with pitch adaptors.

As the front-end hybrids carry many signal lines in a small area other problems due to high speed signals arise such as crosstalk. Apart from optimising the layout of the signal lines, care should be taken to choose good dielectrics (low loss) and metals (skin effects).

Increasing density will often create thermal management problems as the space available for heat sinks decreases and the power density increases. There are many ways to place thermal management devices in these modules for which each time the

three ways of power cooling (convection, conduction, and radiation) should be considered. The heat sink material itself is often also an issue.

With the need for circuits with a very low mass as not to influence particles in their trajectory, HEP front-end electronics differs from modules usually made by industry. To this end CERN has developed a unique process to fabricate multi-layer circuits from polyimide with aluminium conductive layers instead of copper. This process has been used to make circuits for the ALICE pixel detector and for low mass aluminium cables carrying power and data.

To increase the density in commercial applications, industry is developing methods to embed passive components such as resistors and capacitors directly in the circuit board. Even several methods for embedding active components have been tested with good results but they need special treatment of the dices. It is also possible to stack active silicon dies. The way of building these blocks is the basis of embedding active components in PCBs.

Many of these highly advanced technologies are attractive for front-end electronics. However, mass production of them is not easy as our experience with specialised companies has shown. Technology transfer and collaborations are crucial to make mass production a success.

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