

State of the art design of rigid-flex substrates –A manufacturer's point of view

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GS Praezisions AG has been involved in the LHC project by providing electronic substrates for several experiments such as the CMS front-end hybrids, CMS Calorimeter, ALICE Silicon Pixel Detector MCM and others.

Based on the experience with the designs of the various groups and countries we will highlight the common mistakes, opportunities and challenges in modern PCB design.

We conclude that many design related issues can be prevented if a competent PCB manufacturer is involved at an early stage.

Using proven design rules, the cost performance, manufacturability and product reliability can be significantly influenced. The authors will detail the important design rules regarding build up, choice of materials, layout and surface protection. Advantages and limitations of manufacturing methods like plasma etching and laser drilling as well as direct laser imaging will be discussed.

This will help to avoid problems with implementing front end hybrids for the LHC experiments while pushing the limits of standard PCB design.

Summary

Large scale leading edge experiments such as the LHC, invariably push the envelope of standard electronics. The substrate or PCB is one of the most expensive single component that is designed into such electronics. Coupled with the industrial scale of production, it is inevitable that manufacturer and design team closely cooperate and analyze the risks and trade-offs of aggressive (quick and dirty) design vs. manufacturability.

Direct chip attach boards pose further unique challenges in terms of line pitch and surface preparation. When coupled with flex and rigid-flex design, the complexity increases exponentially, namely because of more processing steps, but also because of the mechanical functions of the board. Linked with harsh environmental conditions such as temperature, vacuum, radiation and vibration standard designs will not live up to the requirements.

This paper will introduce briefly current and future circuit board materials and their respective properties with respect to temperature, vacuum, humidity, radiation and high frequency behaviour. The changes in dimension and absorption of moisture of certain base materials, especially Polyimide, are to be taken into consideration during design.

We will discuss the various stack-up options for rigid, flex and rigid-flex design such as "classical", "bikini" and "book binder" and will touch on the trade-off with respect to price and function. Moreover, the properties of coverfilm and the issue of adhesive squeeze out are covered.

The proper design for mechanical requirements such as flatness, stiffness, bending radius, dynamic stress and torque will be laid out. It will be shown how typical designs may overlook stresses during assembly. Moreover, ceramic inlays may be a useful method to combine the advantages of PCB technology with those of hybrids.

We will investigate the influence of temperature and its implication to the design of the PCB. Special attention will be given to drilling and cleaning of blind vias and plated through holes in inhomogeneous material stacks in order to prevent barrel cracking and separation from the innerlayer during temperature stress. Laser, plasma and mechanical drilling methods will be compared to each other. The

various root causes of delamination during manufacture, assembly and operation will be analyzed and we will present the appropriate counter measures.

These include choice of material, matching copper weight with prepreg or adhesive thickness and proper surface preparation.

Passivation of copper surfaces is important for solderability and bondability of hybrid circuits. GS Praezisions AG will share their knowledge gained in application over a ten year period. Common problems are poor bonding yield, Ni/Au corrosion, Ni/Au cracks, probe marks on bond pads, poor wetting, and whisker building. Some of these problems can be alleviated with improved designs while other will require excellent manufacturing control.

In the advent of ever shrinking geometries, new technologies for art work imaging are inevitable. High density lines need to be combined with ever shrinking vias, posing new challenges for imaging, plating and etching. New technologies in each field including their respective limitations are shown such as stacked vias and laser direct imaging.

In conclusion, we would like to stress that an early cooperation with a competent and experienced manufacturer may push the technological envelope while not compromising on reliability and yield. Sufficient time must be allowed for design review and validation.

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