“Integrate-it-yourself” preamp and multiplexer on LTCC substrate, for PbS array

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Introduction

Lead sulfide (PbS) array detectors offer an interesting possibility for NIR spectroscopy. They offer low cost, high linearity and low noise for wavelengths up to 3 μm. However packaging complexity limits typically pixel count to considerably less than 100, if the detector is packaged without multiplexing electronics. An application specific integrated circuit (ASIC) multiplexer circuitry solution for this application is typically too expensive if production volume is hundreds of units.

The purpose of this work is to integrate PbS array detector with the thermoelectric cooler element into a hermetically sealed package. A preamplifying multiplexing circuitry is also integrated into the package. PbS array needs to be temperature stabilised and PbS material is very sensitive for humidity and some gases. That is why PbS array has to be packaged hermetically. The integration of preamplifying multiplexing structure makes it possible to increase the number of detector elements with only slight increase in the pincount.

Method

A preamplifying structure is implemented on to the LTCC substrate (Low Temperature Co-fired Ceramics) into a hermetically sealed package right next to the detector array, which minimises the coupling of the interferences into high ohmic leads. After the signal has been preamplified, it will be serialised by using multiplexers. The LTCC substrate makes it possible to integrate the preamplifier circuitry in a very efficient manner using discrete high quality passive components. LTCC has great electrical properties in wide frequency range. The design rules for typical LTCC process are presented in reference[1].

The number of layers can be easily made 20 with LTCC technology. This makes it possible to produce very high density and high quality substrates. By using either wire bonded ICs (Integrated Circuit) or CSP circuits (Chip Scale Packaged) with the smallest SMT (Surface Mounting Technology) passive components it is possible to make the integration density very high. This is very critical feature in integrating the electronics inside the hermetically sealed packages. It is also possible to integrate passive components into the substrate in LTCC technology. Figure 1 demonstrates some of the possibilities that the LTCC substrate offers. LTCC material is perfectly suited in hermetical environment because its material is ceramic that does not have any outgassing problems.

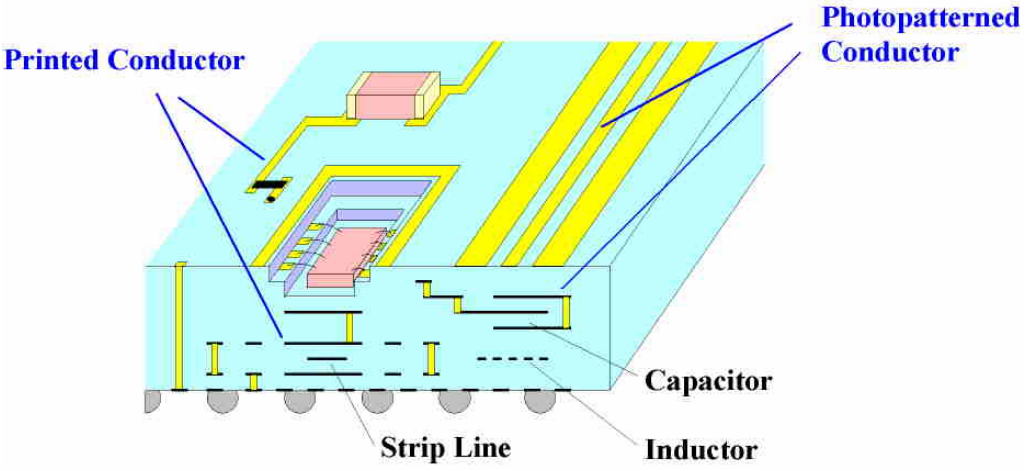

Figure 1. The LTCC substrate and some possibilities that it offers for design.

Results

A 24 element PbS array was integrated into the same package with the preamplifying and multiplexing modules. Figure 2 shows the structure before enclosing it to the package. The modules have 12 channels each and their dimensions are 32 mm * 12 mm. The inner dimensions of the package are 40 mm * 35 mm. The dimensions of PbS array are 28 mm * 7 mm.

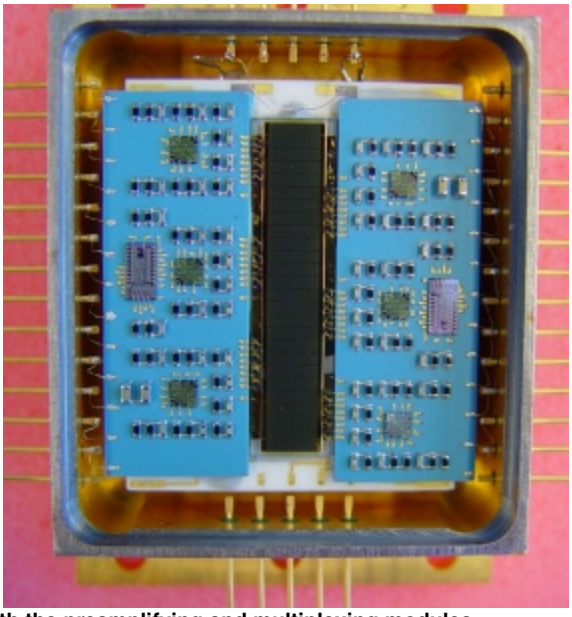

Figure 2. PbS-array with the preamplifying and multiplexing modules.

During the layout design it was also demonstrated that one can reduce size of the 16 channel preamplifying and multiplexing module in 8 mm * 12 mm by using the smallest available passive components and bare chips on both sides of the substrate. This small size would allow one to fit 128 element array with the 8 pieces of 16 channel preamplifying and multiplexing modules into the package shown in figure 2.

The measurements of the structure shown in figure 2 have revealed that by using good layout design procedures one can control the capacitive crosscoupling regardless of small dimensions. Also the detectivity remains high even if the detection procedure used was not typical phase sensitive detection (PSD).

Conclusion

The LTCC substrate technology has many advantages that can be exploited in various kind of radiation detectors. It makes it possible to use standard assembly methods together with high integration grade. For example one can select substrate material on the basis of it's thermal coefficient of expansion so that direct attachment of detector elements to the substrate can be done with high reliability. LTCC has no vapour outgassing problems so it is perfectly suited in hermetical packaging. During this work it was demonstrated that LTCC substrate offers a great possibility to integrate electronics into the same package with the detector array.

Typically production volume for optical detection modules is quite low. LTCC's design and production starting costs are low compared to full ASIC solutions. LTCC is competitive in price in small series production and prototyping is fast. It's mechanical accuracy is high and it is reliable substrate material.

References

1. K. Kautio, Design Guidelines Low Temperature Co-Fired Ceramic Modules. (2000). VTT Electronics, Oulu, Finland URL: http://www.vtt.fi/ele/research/ope/pdf_files/lcdes.pdf