CdTe Double Sided Strip and Pixel Detectors

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Introduction

There has not been a technique to pattern or pixelate the anode side of the In doped p-type CdTe diode, so called M-π-n CdTe diode. This has prevented the use of these CdTe diodes as double sided CdTe strip detectors and 2-dimensional pixel detectors. It has recently been shown, that the double sided strip configuration for CdTe imaging detectors can provide a fine position resolution and large detection areas with a suitable small amount of readout channels. The authors had used Schottky type detectors due to problematic nature to segment the M-π-n CdTe diode.

The Innovation

Prior to ITI activity we have successfully demonstrated a simple method to pattern the thick diffused In anode on the CdTe diode. The method relies on removing the semiconductor material from the preferred locations until the physical junction is reached. As the junction is penetrated, the separated segments become electrically isolated. The removal of the semiconductor material can be done by a pulsed laser beam, etching, diamond blade sawing, or by combining these methods

Results of the ITI activity

The goal of the project is to find best possible method to pattern the anode side of M-π-n CdTe diodes. The methods that have been investigated are diamond blade dicing, femto- (FS) and picosecond (PS) laser patterning. The results so far show best performance for the diamond blade dicing, but this method lags the possibility to dice other patterns than lines or straight trenches. The PS- and FS laser performances were not much worse than with the diamond blade and the laser gives the freedom to pattern non-line patterns, such as common guard rings.

Another goal of the project is to use the patterning method to pixelize the M-π-n CdTe diodes and connect them to CMOS readout ASICs for X-ray imaging and spectroscopy tests. The trials were done with the diamond blade process by dicing perpendicular 20 μm deep trenches with 55, 110 and 250 μm pitches to match the pitch of the Medipix2, Timepix and Hexitec Readout Chips (ROC), respectively. The flip chip bonding was done with conventional “high” temperature SnPb process to Medipix2; with new “low” temperature InSn process to Timepix; and gold stud bonding to Hexitec. All flip chip bonding methods were successful and the imaging results have shown improved polarization tolerance for the anode side patterned diode compared to the cathode side patterned one. In addition, anode side patterned diode showed properties of edgeless detectors. The spectroscopic performance was evaluated with the Hexitec ROC by using an Am-241 radiation source. It has been shown that the patterning process can provide a very good spectral response and a good stability. An average energy resolution of 760 ± 280 eV at 60 keV for a 5x5x1 mm^3 CdTe detector was demonstrated.

The third goal of the project is to build a test bench to characterize CdTe double sided strip detectors. Few approaches have been investigated to make the strip connection to the front-end chips feasible. The best method has been found to be a use of glue and conductive patterns on a thin foil. The first measurements are encouraging and provide a low noise operation. Additional the detectors can be cooled down by using peltier coolers to obtain improved energy resolution and stability. The current double sided strip detector technology is not suitable for large volume production but can be used in special detector applications like in space experiments.

The ultimate goal of the project has been to provide a repeatable process to pattern, handle and flip-chip bond large area (up to 2x2 cm^2) CdTe diodes. Most likely this same process can be used for large area CdZnTe diodes. We have been able to develop it and demonstrate it for CdTe diodes with volumes of 14x14x1 mm^3 and 20x20x1 mm^3. It has been shown that the large area detector has at best similar properties as the smaller ones and high quality imaging can be provided. An issue related to large area processing is a bowing of the CdTe diode after the patterning process. This has raised some difficulties with the flip-chip bonding process.

Future applications

During the ITI activity we were able to improve the technology significantly. The technology gained large attention especially from the groups developing detectors for special applications like synchrotrons. Unfortunately the detectors patterned with laser machining didn’t operate as well as hoped and that reduces the prospects to apply the technology in larger scale, like in medical, industrial and or security applications. But it seems that the technology is attractive for space and special applications.

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