FINAL REPORT

FOR CRADA NO. C-05-08

BETWEEN

BROOKHAVEN SCIENCE ASSOCIATES

AND

EV Products, Inc.

Project Entitled: Development of Multi-window ASIC for High-Flux X-Ray Inspection Systems.

Brookhaven PI: James Lemley

Submitted by: Michael J. Furey
Manager, Research Partnerships
Brookhaven National Laboratory

DISCLAIMER

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Project Entitled: Development of Multi-window ASIC for High-Flux X-Ray Inspection Systems.

Brookhaven PI: Paul O'Connor

Submitted by: Michael J. Furey
Manager, Research Partnerships
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FINAL REPORT - February 22, 2007
CRADA BNL-C-05-08

TITLE:	Development of Multi-Window ASIC for High-Flux X-Ray Inspection Systems
TECHNOLOGY AREA:	Microelectronics
BROOKHAVEN PI(s):	Dr. Gianluigi De Geronimo, Instrumentation Division, 631/344-5336, fax 631/344-5773, degeronimo@bnl.gov Dr. Paul O'Connor, Instrumentation Division, 631/344-7577, fax 631/344-5773, poc@bnl.gov
INDUSTRY PARTNER(s):	eV Products, Inc., PI: Fred Ferraro 375 Saxonburg Blvd. Saxonburg, PA 16056 724/352-5234
DURATION:	12 months
OBJECTIVE:	Develop a 64-channel ASIC capable of processing pulses delivered by CdZnTe X-ray sensors at rates up to 2,000,000 pulses per second.
DOE FUNDS:	No DOE Funding requested for this project

INDUSTRY CONTRIBUTION:

FY05	FY06	Total
$46,526	$139,579	$186,105
Total Funds-In:		$186,105
Total In-Kind:		--

FINAL REPORT: See next pages

Project Summary

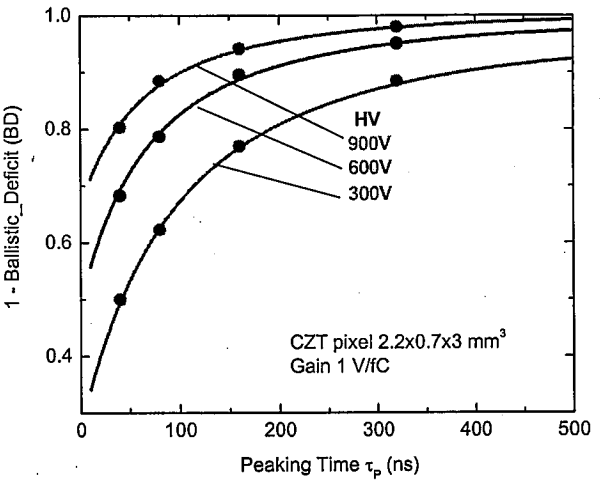
The BNL Microelectronics group has designed a series of custom ASICs in CMOS technology for use with Cadmium-Zink-Telluride (CdZnTe) radiation detectors, primarily in the field of nuclear spectroscopy. An increased demand for CdZnTe based detection systems that can operate in high flux X-ray inspection equipment makes it necessary to develop a new type of signal processing ASIC, one which can achieve moderate energy resolution at very high count rate. This work covers the development of a high-rate, low power ASIC that classifies events into one of five energy windows at rates up to 2 MHz/channel.

Significant Accomplishments

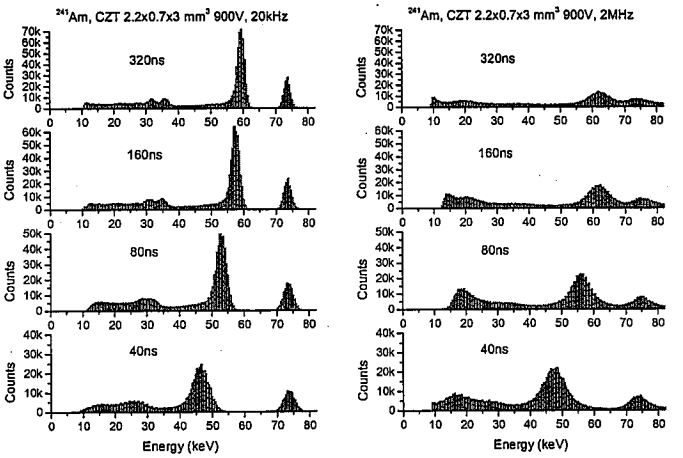
Extraction from a report of eV Products.
"Over the course of the CRADA, three iterations of the design were produced and tested. The first and second design iterations were used to validate the design approach for various elements of the overall design, identify areas of the design that did not meet requirements, and identify issues in the MWASIC test system. The third design iteration was used to verify the performance of the MWASIC against the design requirements and to validate its functionality against X-Ray imaging system parameters.
The first design iteration was submitted for fabrication on 21-March-2005 and tested during September-2005. Several major performance issues were found during the testing of this design. These include oscillations in the analog circuit section of the design when all 64 input channels were powered, oscillations in the analog circuit section of the design when certain channel gain and peaking time combinations were selected, the analog baseline became unstable at count rates above 200khZ, the gain dispersion across all 64 input channels was too large, the dispersion of the five threshold DAC's was too large and the dynamic range of the analog circuit section of the design was drastically reduced when the MWASIC was operated at a temperature of 50°C or higher. The root cause for each of these issues was determined through experimental and/or analytical methods and solutions were developed for implementation in the second design revision.
As the design of the first MWASIC was being developed, and later, as the design was being fabricated, a test system for the MWASIC was being developed. The test system included two custom PCB's used to interface the MWASIC to read out electronics, firmware to process/transmit X-Ray count data to a PC, firmware to interpret instructions received from the PC and a Graphical User Interface (GUI) used to control the system and visualize the X-Ray count data received from the MWASIC. This test system was incrementally improved throughout the project and was used to test all three design iterations.
The second design revision was submitted for fabrication on 28-Nov-2005 and tested during Feb/Mar-2006. Many of the performance issues identified in the first design were found to be resolved. Those that were not resolved were improved however, additional work needed to be done to bring these remaining issues in line with the design requirements. The issues identified in the second design include oscillations in the analog circuit section of certain channels with a specific combination of channel gain and peaking time, a large gain dispersion across all 64 input channels and a large dispersion of the five threshold DAC's. Additional information was gathered concerning the root cause of these issues and the solutions were targeted for implementation in the third design revision.
The third design revision was submitted for fabrication on 22-May-2006 and tested during Sept-2006. Minor issues were found with the performance of this design that include a higher

than expected dispersion of the five threshold DAC's that is due to DAC #3 being slightly different than the other four DAC's and a floating channel issue when a channel is masked. Neither of these issues is expected to have an affect on the performance of an X-Ray imaging system that uses the MWASIC."

Below are two experimental results from the developed CZT-ASIC system [1].



Measured ballistic deficit vs peaking time extracted from measurements on 2.2×0.7×3 mm^3 CdZnTe pixels biased at 300, 600, and 900 V.



(a) (b)

Measured ^{241}Am spectra vs. peaking time at a rate of (a) 20 kHz and (b) 2 MHz with CdZnTe 2.2×0.7×3 mm^3 pixels biased at 900 V. The test pulse at 73 keV is also shown.

Significant Problems

No significant problems were observed or reported.

Industry Benefits Realized

Extraction from a report of eV Products
"The success of CRADA BNL-C-05-08 will allow eV PRODUCTS to expand the product offerings in many X-Ray imaging markets where our current offering is non-ideal or non-

existent. In the coming months eV Products expects to complete the development of products that will improve the capabilities of X-Ray based food inspection equipment, baggage inspection equipment and specialized medical equipment such as bone densitometers."

Laboratory Benefits Realized

BNL extended its knowledge in CdZnTe based CPG sensors for isotope identification field and technologies associated with high-resolution and high-rate gamma-ray imaging, an area of active research in the Laboratory. The results from the MWASIC have already attracted collaborators within and outside BNL in view of other applications. The architecture of the MWASIC has been jointly patented by BNL and eV Products.

Recommended Follow-On Work

None at this time

References

[1] G. De Geronimo, A. Dragone, J. Grosholz, P. O'Connor, E. Vernon, *ASIC with multiple energy discrimination for high rate photon counting applications*, IEEE Proc. 2006 Nuclear Science Symp., San Diego, Oct. 2006, IEEE Transactions on Nuclear Science, in press.