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Manufacture of Dual Sided Microstructured Semiconductor Neutron Detectors

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Abstract

The world is in need of a new way to detect neutrons. The best current detectors rely on ^{3}He, which is in short supply. The ^{3}He detectors are extremely expensive. The goal of this project is to produce inexpensive and robust detectors that do not rely on ^{3}He. Instead of using gas, the Dual Sided Microstructured Neutron Detectors (DS-MSNDs) are made from a semiconductor material. The DS-MSNDs have been simulated to have up to 70% efficiency, which is comparable to the ^{3}He detectors efficiency of about 80%. The DS-MSNDs have micro-trenches that are back filled with ^{6}LiF, a neutron reactive material. Trenches for the devices are created using standard VLSI processes and techniques. Over the past year, small changes have been made to the manufacturing process to yield more consistent results in the trench depths, packing fraction, and intrinsic neutron detection efficiency. Some of the changes made to the manufacturing process are etching times, particle size of the ^{6}LiF, and packing techniques. The best detectors are taken and tested with a Californium-252 source to find out the intrinsic neutron detection efficiency. The efficiency is found by comparing the counts taken by the device and comparing that value to another device with a known efficiency. The highest efficiency a device has achieved is 69.2%.

Methods

- Devices are made using standard VLSI processes and techniques
- ^{6}LiF is packed into the trenches
- Devices are mounted onto electronics
- Tested using Cf-252 source
- Count rate is directly compared to detector with known efficiencies

Results

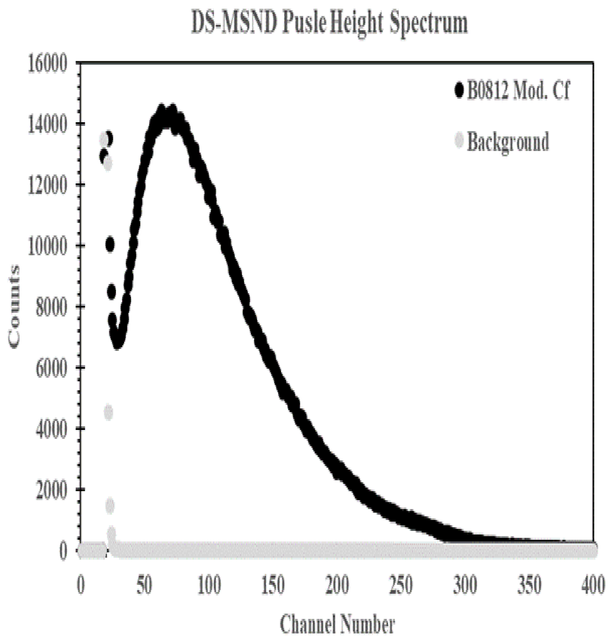

Figure 1 (top): Spectrum produced from DS-MSND

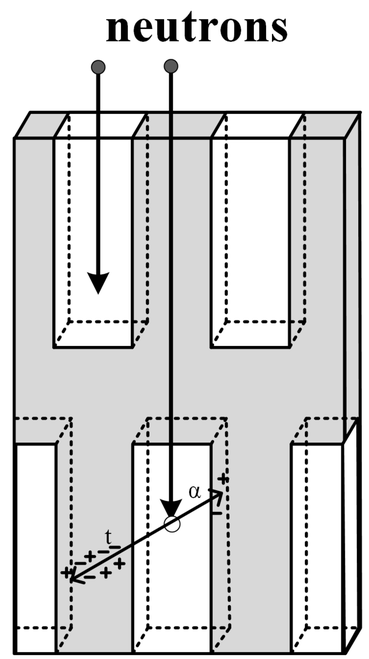

Figure 2 (right): Structure of DS-MSND

Diode	Detection Efficiency	Err. Det. Eff.
B0802	65.1%	0.7%
B0804	64.0%	0.7%
B0806	66.6%	0.8%
B0811	68.1%	0.8%
B0812	**69.2%**	**0.8%**
B0814	65.1%	0.7%

Figure 3: Chart shows efficiency of different detectors

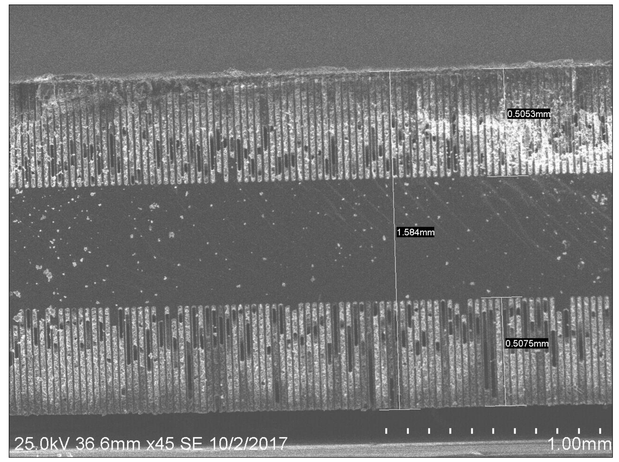

Figure 4:Picture of a DS-MSND taken using a Scanning Electron Microscope (SEM).

Conclusion

In conclusion, the current methods of manufacturing has produced detectors with up to 69.2% efficiency. This is an improvement over the previous generation of detectors, which had an efficiency of 54%. The next step is to consistently produce devices with an efficiency of over 65%. The final goal is to have a marketable product.

References

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[2] R. G. Fronk *et al*., "Advancements on dual-sided microstructured semiconductor neutron detectors (DSMSNDs)," *2015 IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC)*, San Diego, CA, 2015, pp. 1-4. doi: 10.1109/NSSMIC.2015.7582287

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