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Wrapping Scintillator Crystals to Optimize Light Collection

INTRODUCTION

The purpose of this Application Note is to give recommendations that improve the performance of scintillators read out with Silicon Photomultiplier (SiPM) sensors from ON Semiconductor.

SiPMs have been shown to be a valuable alternative to traditional vacuum PMTs, especially for the readout of (< 10–20 mm) scintillator crystals for gamma, particle and X-ray spectroscopy. The performance of scintillator-SiPM detector assemblies is characterized by the FWHM energy resolution and the achievable low-energy threshold. Such performance is highly dependent on the light-collection efficiency from the scintillator to the SiPM. With the proper set-up, SiPMs outperform vacuum PMTs, and offer the ability to develop next-generation medical and hazard and threat detection systems.

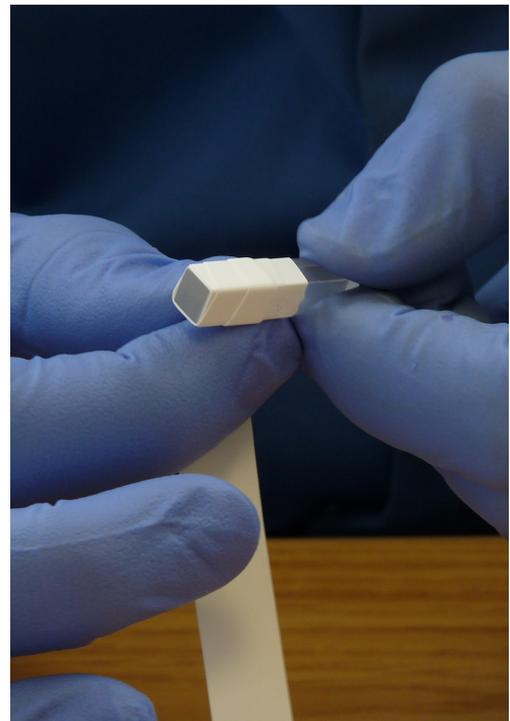
SCINTILLATION CRYSTALS AND THEIR RECOMMENDED SHAPING TIMES

Some commonly used scintillation crystals are:

- CsI(Tl)
- BGO
- LYSO

One should note that these three crystals have different scintillation decay times and therefore different shaping times should be used for optimum performance. Generally, a delay-line shaper or gated integrator gives the best performance, but CR–RC or semigaussian shapers are more widespread. For the optimal performance, the preamplifier should be configured as an integrating preamplifier.

APPLICATION NOTE



Scintillator	Characteristic Decay Time	Recommended Integration Time for Delay Line Shaper or Gated Integrator	Recommended Shaping Time for CR–RC or Semigaussian Shaper
CsI(Tl)	Two components; can be approximated as single 1 μ s	3–4 μ s	4–5 μ s
BGO	300 ns	1 μ s	500 ns
LYSO	40 ns	200 ns	250 ns

COUPLING THE SCINTILLATION CRYSTAL TO THE SiPM

For good light collection efficiency one should take the following measures:

1. The crystal size and SiPM active area should match each other. That typically means that the size of output face of the crystal is coupled to a SiPM of the same dimension (3 x 3mm² or 6 x 6 mm²).
2. Optical coupling grease such as Bicon BC-630 should be applied between the SiPM and the crystal. For permanent mounting, one should use special transparent glues or cements like the Meltmount™.
3. The remaining five scintillator crystal surfaces that are not coupled with the SiPM should be covered with a diffuse light reflector. One of the best and most easily available materials for that is teflon tape.

RECOMMENDED REFLECTOR MATERIAL

One of the best and most easily available materials for crystal wrapping is teflon tape, particularly the white teflon (PTFE) tape used for household plumbing. It is important to note that generally there are two types of such tape available:

1. Thin, used mostly for water tube joints.
2. Thick (so called gas quality tape), used mostly for gas tube joints.

We recommend type 2 (gas quality) as it has demonstrated significantly better performance. In addition, it is easier to use. The example of such tape is pictured on the following page, and commonly found in shops for household appliances, e.g:

<http://radionics.rs-online.com/web/p/products/231-964/>
http://www.homedepot.com/h_d1/N-5yc1v/R-202280370/h_d2/ProductDisplay?langId=-1&storeId=10051&catalogId=10053



APPLYING THE REFLECTOR MATERIAL

An undamaged length of the Teflon tape should be carefully unwound from the reel, and laid on the work surface. To determine the typical length of tape required to wrap a small crystal, please refer to the table below.



Crystal Size	Length of Teflon Tape
3 x 3 x 15 mm ³	13 cm
6 x 6 x 30 mm ³	42 cm

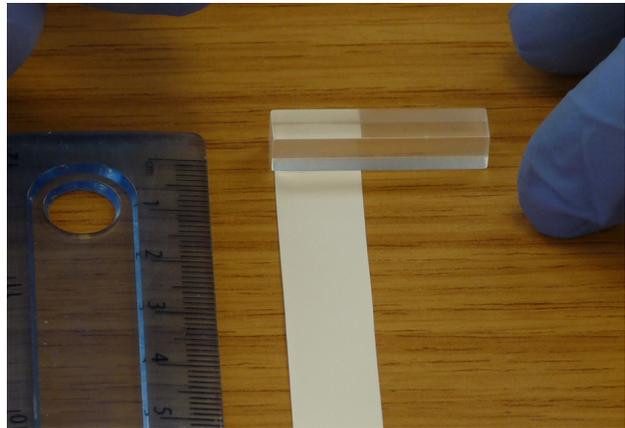


Figure 1. Ensure that the Crystal is Clean and Free of Marks from Finger-prints etc. Carefully Lay the Crystal onto the Tape, Ensuring that the Exit Face Edge is Aligned to the Edge of the Tape

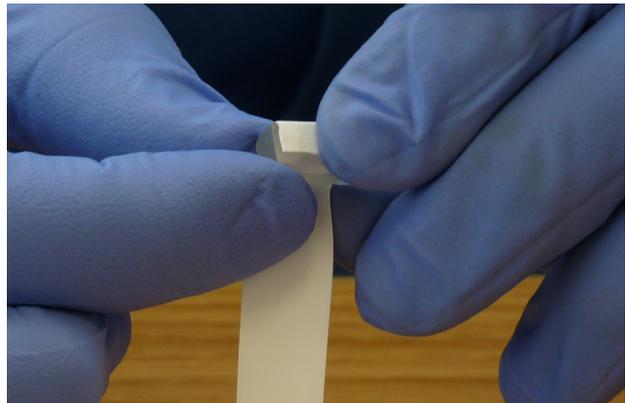


Figure 2. Start to Carefully Wrap the Teflon around the Crystal, Ensuring that the First Wrap Neatly Aligns the Tape Edge with the Edge of the Crystal. Take Care to Avoid Covering Any of the Exit Surface with the Tape

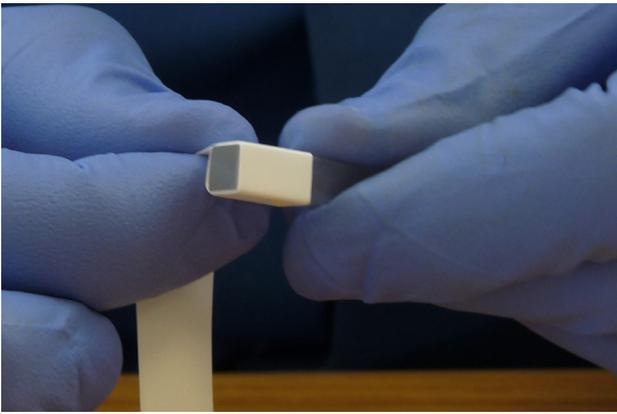


Figure 3. After the First Wrap, Cover this Same Area with at Least Another Two Layers. You Should Aim to Have 3 Layers of Teflon Tape Covering the Five Non-exit Surfaces of the Crystal

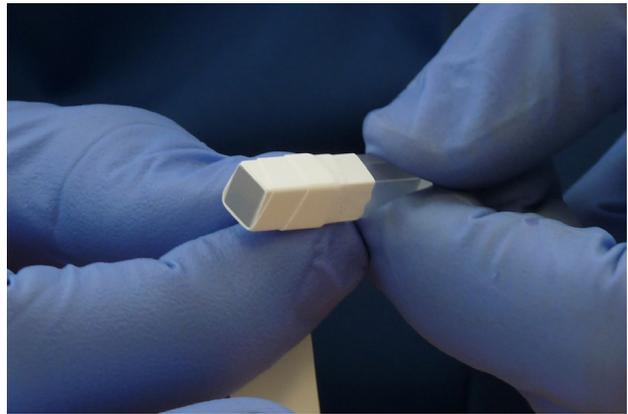


Figure 4. Continue to Wrap Up the Length of the Crystal Avoid Wrinkles or Damage to the Tape. Aim for 3 Layers of Teflon Coverage

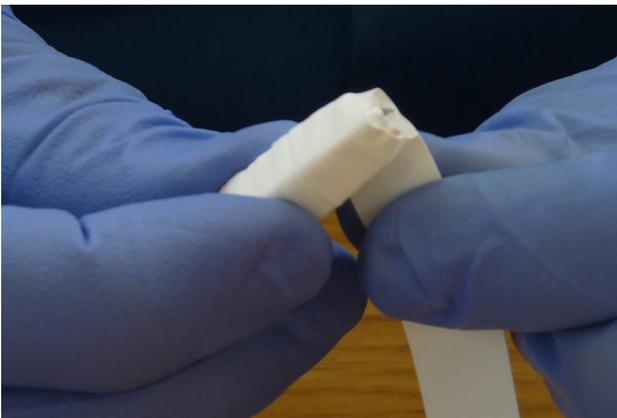


Figure 5. Continue to Wrap Until the Tape is Generously Overlapping the End. Ensure there are 3 Layers of this Overlap

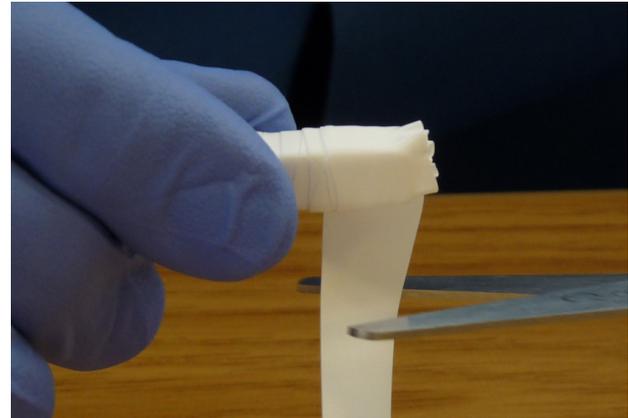


Figure 6. Cut Off Any Excess Tape and Wrap the Tape End Around the Crystal. The Teflon Tape Adheres to Itself Well Enough that it Should Stay in Place by Itself



Figure 7. Pinch Together the Overlapping Ends of the Teflon Tape to Seal the Face Opposite the Exit Surface of the Crystal. Ensure that it is Done Tightly so that it Remains Secure



Figure 8. The End will Look Like This. The Point can be Trimmed Off if Desired. The Wrapped Crystal is Now Ready for Use

AND9774/D

One should note that over time optical grease may get partially absorbed by the teflon tape causing noticeable deterioration of light reflectance. Therefore,

ON Semiconductor recommends rewinding the crystal after every measurement to ensure the best light collection.

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