CsI(Tl), CsI(Na)
Cesium Iodide
Scintillation Material

Cesium Iodide is a material with high γ-ray stopping power due to its relative high density and atomic number. For scintillation counting, it is used either in its undoped form or doped with sodium or thallium. CsI is resistant to thermal and mechanical shock.

The physical characteristics of CsI are independent of the activator used. Compared to NaI(Tl), it is relatively soft and plastic, and does not cleave. Because it has no cleavage plane, it is quite rugged – which makes it well-suited for well logging, space research or other applications where severe shock conditions are encountered.

CsI is slightly hygroscopic. Contact with water and high humidity should be avoided.

CsI(Tl) –

CsI(Tl) is one of the brightest scintillators. The maximum of the broad emission is situated at 550nm and the emission is, therefore, not well matched to a bialkali photocathode photomultiplier tube. This results in a photoelectron yield for γ-rays which amounts to 45% of the value for NaI(Tl). Figure 1 shows the emission spectrum.

Since CsI(Tl) has most of its emission in the long wavelength part of the spectrum, the material is well-suited for photodiode readout. CsI(Tl) has a light output of 54 photons/keV and is one of the brightest scintillators known.

Due to its higher average atomic number, the photofraction of CsI(Tl) is higher than that of NaI(Tl). For some applications this can be advantageous.

CsI(Tl) is a relatively slow scintillator with an average decay time of about 1μs for γ-rays. Electronics with suitable shaping times (4-6μs) should therefore be used. This limits the high count rate capability of the detector.

Properties	
Density [g/cm³]	4.51
Melting point [K]	894
Thermal expansion coefficient [C^{-1}]	54 x 10^{-6}
Cleavage plane	none
Hardness (Mho)	2
Hygroscopic	[a] slightly [b] yes
Wavelength of emission max [nm]	[a] 550 [b] 420
Lower wavelength cutoff [nm]	[a] 320 [b] 300
Refractive index @ emission max.	[a] 1.79 [b] 1.84
Primary decay time [ns]	[a] 1000 [b] 630
Light yield [photons/keVγ]	[a] 54 [b] 41
Photoelectron yield [% of NaI(Tl)] (for γ-rays)	[a] 45 [b] 85
Material type key [a] CsI(Tl) [b] CsI(Na)	

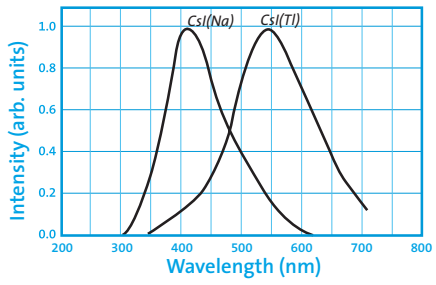

Figure 1. Scintillation emission spectrum of CsI

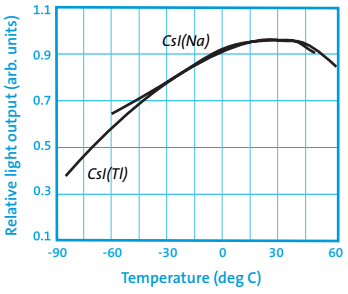

Figure 2. Relative light output as a function of temperature for CsI

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CsI(Tl) – (continued)

The decay time of CsI(Tl) consists of more than one component. The fastest component has a value of about 0.6μs, the slowest 3.5μs. For excitation with highly ionizing particles, such as α-particles or protons, the ratio between the intensity of these two decay components varies as a function of the ionizing power of the absorbed particle. CsI(Tl) scintillation crystals can therefore be used for particle discrimination using pulse shape analysis.
It has been demonstrated that nuclei up through Li can be identified this way.

Radiation damage of CsI(Tl) scintillation crystals may become significant above doses of 10 Gray (10^3rad). About 10 to 15% light loss has been measured. However, some of the damage is reversible.

CsI(Na) –

As shown in Figure 1, the emission maximum of CsI(Na) peaks at 420nm and is well matched to the photocathode sensitivity of a bialkali photomultiplier. The photoelectron yield for γ-rays amounts to 85% of NaI(Tl). The decay time of CsI(Na) at 630ns is less than that of CsI(Tl).

Temperature Response –

Figure 2 shows the dependence of the scintillation light output as a function of the temperature. The maximum scintillation emission intensity for CsI(Na) and CsI(Tl) is measured at about 25 to 30°C, and the change in light output with temperature is about 0 in this range.

Low background CsI –

Low background CsI has been developed for certain applications that require reduced levels of K, Th, U, and Rb.

Photodiode Readout –

Since CsI(Tl) has most of its emission in the long wavelength part of the spectrum (>500nm), it is well-suited for photodiode readout.

Photodiodes are available in a variety of sizes. The size of the photodiode should be such that a maximum amount of scintillation light can be detected. We have standardized detectors using 10x10mm^2 and 18x18mm^2 photodiodes., the smaller ones allowing lower noise levels. Compact detectors with built-in photodiodes are available.

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