BaF_2
Barium Fluoride Scintillation Material

Barium fluoride (BaF_2) is presently the fastest known scintillator. It has an emission component with subnanosecond decay time that yields very fast timing. Fast timing is required for positron lifetime studies, time of flight measurements, Positron Emission Tomography (PET) and certain high energy or nuclear physics applications. Using special electronics, time resolutions around 200 ps are possible for small detector geometries.

There are several new scintillators that also have excellent timing capabilities. These are BrilLanCe™ 350, BrilLanCe™ 380 and PreLude™ 420. Please see corresponding data sheets for each of these materials.

BaF_2 has several scintillation emission bands. The fast scintillation light is emitted in the UV in bands centered at 220 and 195nm. The decay time of the fast component varies between 600 and 800ps.

To detect the fast scintillation light, it is necessary to use a photomultiplier tube with a quartz entrance window. Furthermore, the optical coupling compound must have a good transparency for UV light. Usually silicon oils or compounds are used.

The self-absorption of the material is very low so that the use of large scintillation crystals is possible.

Next to the fast emission components, BaF_2 also emits a relatively slow scintillation component in a band centered at 310nm. The decay time of this component has an average value of 630ns.

Using quartz photomultiplier tubes for the detection of the scintillation light, about 15% of photoelectrons is produced by the fast component whereas 85% originates from the slow component (γ-rays). The total number of photons emitted from a BaF_2 crystal is about 12 per keV of photon energy.

Properties	
Density [g/cm³]	4.88
Melting point [K]	1627
Thermal expansion coefficient [C^{-1}]	18.4×10^{-6}
Cleavage plane	<111>
Hardness (Mho)	3
Hygroscopic	slightly
Wavelength of emission max [nm]	310 220(195)
Lower wavelength cutoff (nm)	135
Refractive index @ emission max.	1.5 (310nm) 1.54 (220nm)
Primary decay time [ns]	630 (slow) 0.6 - 0.8 (fast)
Light yield [photons/keVγ]	10 (slow) 1.8 (fast)
Photoelectron yield [% of NaI(Tl)] (for γ-rays)	16 (slow) 3 (fast)

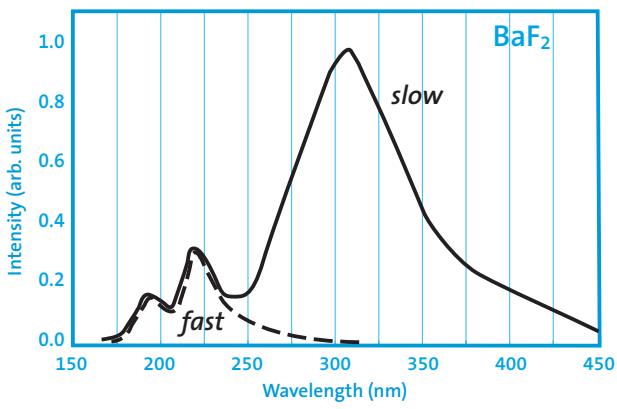

Figure 1. Scintillation emission spectrum of BaF_2

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The ratio between the intensity of the fast and the slow scintillation components of BaF_2 depends on the ionizing power of the absorbed particle. This feature allows gamma discrimination and particle identification by pulse shape discrimination techniques. (References below.*)

The response of BaF_2 to neutrons up to 22MeV has been investigated. (Reference below**.)

The scintillation intensity of the fast component is independent of temperature between -40°C and 25°C. The slow component varies gradually with temperature, attaining its maximum at -10°C. (V.Nanal et al., *Nuclear Instruments and Methods in Physics Research*, A389, 1997, 430-436).

BaF_2 is not hygroscopic, but condensing moisture can pit its surface. It is relatively radiation hard. Radiation doses of 10^5 Gray (10^7 rad) do not cause any severe damage to its scintillation characteristics.

References:

* NIM A376 (1996) 108-212
NIM A312 (1992) 515-520
NIM A269 (1988) 595-598

** NIM A274 (1989) 501-506

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