## Scintillators for the SEM - A Practical Guide

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The scintillator Is a part of the electron collection system in most SEMs and other types of electron imaging systems. Without a properly functioning scintillator, images may be noisy, weak, or exhibit other signs of degradation.

There are three types of scintillators generally used in the SEM: organic/polymeric, phosphor powder, and crystalline (single or poly).

Plastic scintillators are currently used less frequently, mainly because they are subject to radiation damage (*i.e.*, short lifetime). This type of scintillator has the shortest decay time (~2.2 - 5 ns) and very low noise. We still have many customers who prefer this type of scintillator even though they have to change it more frequently (~2 - 6 month lifetime with average use is our experience). Using a quartz substrate, the scintillator material in liquid form is spin coated to produce a uniform thin film. This method makes a more robust product and introduces a minimum of organic material to the high vacuum system. The films are over coated with aluminum for conductivity.

Various phosphor powders have been in use, but the SEM market seems to prefer the P47 line of materials. They are generally produced by settling in proprietary solutions, with or without binders, on glass/quartz. In most cases a conductive layer on top has been found unnecessary. The grain size of the phosphor, thickness of the layer, and other additives to the settlement tank can vary the results. The phosphors have a longer decay time (~20 - 40 ns), but still within bounds to be used as fast scan rates. They last 2-3 times longer than plastic scintillators - as long as the vacuum is clean. A contamination layer on the surface of any scintillator will reduce its efficiency.

Crystalline scintillators such as YAG:Ce, YAP:Ce, CaF:Eu, etc., are generally cut and polished from a larger boule of known crystallographlc orientation. The production method makes them the most expensive (4 - 8 times the cost of phosphor or plastic). They offer the advantage of a long lifetime and are quite robust. Since the light output does not match the peak spectral range of most photomultipliers in SEMs, and the decay time is 40 - 80 ns, the resulting signal is a little less than other types of scintillators. On the other hand, the signal strength stays higher over the lifetime than the plastic or phosphor scintillators; assuming contamination is not a problem. Unlike other types, the crystalline scintillators can be cleaned and re-coated with aluminum. Because of the high cost, we only recommend these scintillators in special circumstances. Many customers order the single crystal screens for use with CCD cameras. Because it is single crystal, the background appears structureless as opposed to phosphor powders. The main problem in production is getting the material thin (< 0.25 mm) enough for optimum resolution. Some novel methods are currently in the prototype stage to overcome this limitation.

The scintillator should be handled with the utmost of care since it is very fragile. Never touch the coated surface. Install so that the active / coated side is facing towards the sample chamber and held securely in place with the scintillator retaining ring. Contact of the scintillator retaining ring with the surface is required for conductivity. Application of silver paint at this interface is no longer recommended. Upon installation, it is recommended that the SEM pump on the sample chamber for 30 - 60 minutes to allow any residual gases to be pumped off.

Unless used in the backscatter mode the scintillator has a 9 - 12 Kv bias voltage applied. If arcing occurs in the area of the scintillator, damage could occur. Furthermore, if scintillator material is removed in any manner (looks like pinholes), the underlying substrate may also charge up. This type of problem is rarely seen in the modern SEM due to a better vacuum environment.

It is difficult to say how long a scintillator will last due to the many variables. The biggest problem is the back streaming of oil from the rotary pump (or possibly the diffusion pump; although less likely). The oil vapor condenses on the scintillator as well as on the EDS detector window. A foreline trap with replaceable elements should eliminate that concern. Make sure the copper element in the foreline trap is changed on a regular basis - usually every 4 - 6 months.

All things being equal, the scintillator wears much like a florescent bulb - slowly. The degradation cannot be noticed on a day-to-day basis, but when you finally change it the whole world lights up! Many service engineers change them every 6 months during a regular maintenance check. After all, if the scintillator later turns out to be a problem, an expendable part that usually costs under $100 could cost an additional service visit at hundreds of dollars. We encourage SEM operators to learn to change the scintillator to save time and money. Most scintillators are shipped hermetically sealed so shelf life is indefinite. If the package is opened, or not sealed at the factory, store scintillators in a vacuum desecrator if at all possible.