Technical Insight

Title: Coating of Frits: Can we really coat all of the internal passages?
Initiated Date: 08-13-18
Submitted Date: 08-30-18
Author(s): Jesse Bischof

Background:

Sintered metal frits are made by pressing powdered metal together and heating the pressed material up until the discrete metal particles are fused into a tortuous network of pores and channels. Frits are used in a variety of industries for their ability to filter out unwanted particulate, or to keep particles in place during operation. While there are many benefits to using a metal sintered frit due to their robust nature, the metal they are made from is often too reactive for efficient use. Issues such as filtered particles sticking to the metal surface and clogging the frit or reactive molecules being adsorbed to the frit internal network are common. SilcoTek's anti-fouling and inert coatings can offer a barrier between the metal in the frit and the reactive material.

Coating a frit via common coating techniques such as paints, epoxies, or PVD is not trivial. Common challenges include complete coverage of all the internals, including blind holes, depositing a thin enough coating as to not block the pores and allow the frit to still act as a filter, and consistent coating throughout the frit's inner network. This technical insight will discuss SilcoTek's CVD coating technique and how it addresses these concerns for the coating of frits.

Discussion / Data / Links:

Does the coating penetrate then entirety of the frit?

This is the most common question asked when discussing the coating of a frit, as many coating techniques are "line of sight". As described in Figure 1, SilcoTek's CVD coating is considered non-line of sight, meaning that it can penetrate into tortuous networks and coat blind holes where other techniques such as PVD can only coat areas that point in the direction of the deposition source.

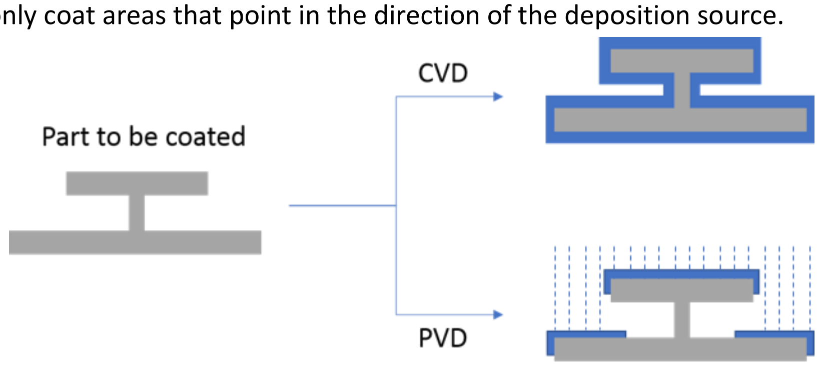

Figure 1: A CVD coated part will be conformally coated around the entirety of the part, while a part coated via a "line of sight" method such as PVD only coat areas that are facing the source of the coating. This will leave areas uncoated and exposed to the environment around the part.

Complete coverage was confirmed by performing a coating on a 2 µm stainless steel sintered frit. The frit was coated with SilcoNert 2000, broken in half to expose the internal network of the frit, and examined via scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS). Figure 2 shows an SEM micrograph of the internal network of the sintered frit. It is a very porous media that contains numerous blind holes. Figure 3 shows an EDS map of that same area. The silicon coating penetrates through the entire frit. While there are areas in the map that no signal is found, note that these same gaps and holes occur in the iron signal from the underlying substrate. These are shadow effects from signal not reaching the EDS detector.

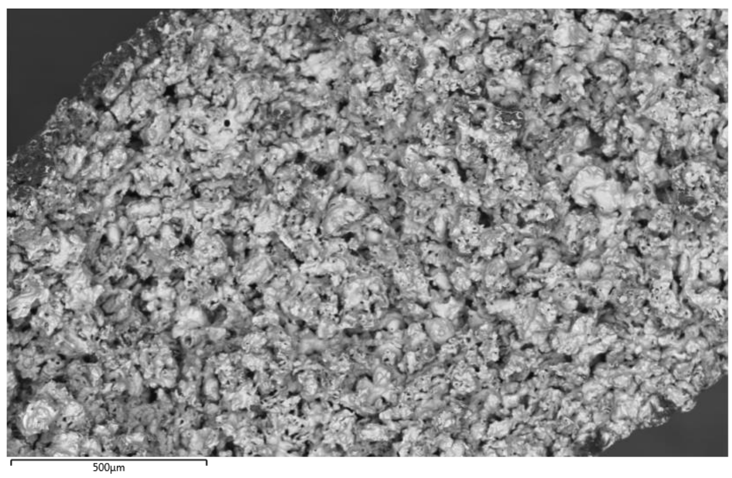

Figure 2: Electron micrograph of a 2 µm stainless steel filter's internal network

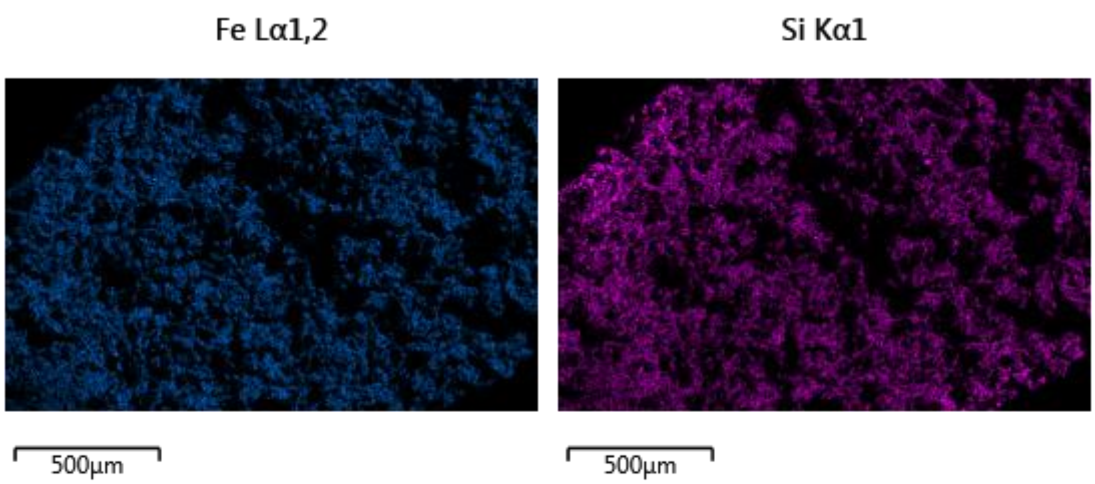

Figure 3: The iron (left) and silicon (right) signal from the frit. The dark spots are shadowing effects from the rough nature of the frit. The entirety of the internal network is coated with silicon.

Does the coating block the pores?

SilcoTek's coatings are typically hundreds of nanometers thick. When a customer is looking at applying our coating to a frit, this number rightfully causes hesitation. If a frit has an average pore size of 2 µm, a 500 nm coating will cut the average pore size in half. This can lead to serious back pressure issues for the customer. Fortunately, this specification of our coating is for flat solid surfaces. On a part like a frit which has a very high surface area to volume ratio, this thickness will be much lower on internal surfaces. The 2 µm frit described above that was coated with our standard SilcoNert 2000, had an internal thickness range of 50 to 80 nm as measured with a Filmetrics F40 film thickness measurement tool. Customers should be aware that the application of our coating may require a slightly higher pressure to accomplish the same flow through the frit, but not to a significant degree. This can be confirmed utilizing a flow/bubble point test.

Is the coating consistent through the entire frit?

When an amorphous silicon deposition is under a micron thick, a slight variation in thickness can cause a dramatic change in color. When a flat surface is exposed to process gas at high temperatures, things such as fill dynamics of the gas, slight temperature variations in the part, and surface roughness can all cause the growth rate of the coating to vary slightly. This is why our typical coatings have a rainbow-like appearance. Figure 4 shows a cross sectional photo of the frit after it has been broken in half. There are three distinct colors in the frit: gold which measures ~50 nm, pink which measures ~65 nm, and blue which measures ~80 nm. Raman spectroscopy was performed to ensure that the material that was deposited on the inner most portion of the frit was the same as the material on the exterior, and it was confirmed that the coating is an amorphous silicon coating, which is what makes our SilcoNert 2000.

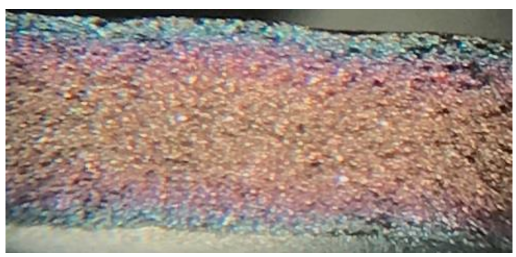

Figure 4: Cross section of a frit that was coated with SilcoNert 2000. While there is a gradient of thickness from the center of the frit to the edges, the difference in coating thickness is only about 30 nm from the center to the edge.

Conclusion:

SilcoTek can conformally coat the internals of fritted materials utilizing our patented CVD technology. These coatings are superior to line of sight coatings such as PVD which would not be able to penetrate into the tortuous network that a typical sintered frit might have. Here a SilcoNert 2000 coating on a 2 µm stainless steel frit was found to conformally coat the entirety of the frit, be thick enough through the internals to act as a good barrier between the environment and the steel, thin enough to not block any pores or cause back pressure issues, and finally is consistent through the entire frit within ~30 nm of thickness variation. Customers that are experiencing activity or corrosion issues between their system and a bare metal frit should consider SilcoTek's coatings to provide the protection necessary for optimal performance.