Cleaning Lines

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A cleaning line is a sequence of procedures that complement each other and result in a surface being cleaned to the desired level, at least temporarily. The cleaning line may be manual, where the parts are transferred from one stage to the next by an operator, or it may be automated, where the movement of the parts is automatic and pre-timed, or it may be a mixture of the two. In some cases the parts to be cleaned may be held by special cleaning fixtures (racks) and the parts must be placed on the holders (“racked”) and removed from the rack after cleaning. In other situations the cleaning rack is also used as the deposition fixture. This has the advantage that only the fixture has to be handled in transferring the parts from the cleaning line to the deposition system. A disadvantage is that the fixtures may have to be stripped of deposited film before they can be used for cleaning again. In some cases the cleaning line is integrated into the deposition line so there is no handling or storage between the cleaning sequence and the film deposition process.

More commonly, however, cleaned parts are handled, stored, and transported either individually or in their fixture after the cleaning operation.

Figure 1 shows a typical tank-type cleaning line using aqueous alkaline cleaning. The cleaning solution is applied both by immersion and spraying followed by both spray and immersion rinsing and finally hot-air blow drying. Immersion with chemical action is used for removing films and surface layers from substrate surfaces. Immersion with agitation and perhaps mechanical brushing, is often effective in removing contaminants such as particulates. In some cases ultrasonic cavitation and agitation are desirable. Electrocleaning can be incorporated into the alkaline cleaning tank. If there is appreciable oil contamination, the first tank should be equipped with a “skimmer” or it should use “overflow” to skim the surface so that the parts are not extracted through an oil film when they are lifted out of the tank.

Immersion cleaning has the advantage that “soaking” can be used for removing or “loosening” contaminants. Immersion cleaning has the disadvantage that cavities fill with fluid, and the cleaning fluid can become saturated with contaminants and stagnant in that region. Spray cleaning and rinsing has the advantage that “hideouts,” such as cavities, are continuously drained and refilled. Spray pressure should be as high as possible without damaging the substrates or knocking them loose from the rack. It may be desirable to mechanically move the parts in each step to aid in cleaning and draining.

It is important that the parts are not allowed to dry between cleaning stages. This means that the transfer between tanks should be as rapid as possible and the air above the tanks should be humid. In some cases the cleaning line should be enclosed in a plenum to obtain better control of the environment surrounding the cleaning line. The plenum can be solid with access doors, or a “soft-wall” to allow access to the cleaning line at any point. The soft-wall can be made of plastic sheets or strips. The plenum can be slightly pressurized with clean filtered air to further control the cleaning environment. The plenum also allows easier venting of vapors from the cleaning area.

Rinsing is important at several stages of cleaning. Rinsing between cleaning steps prevents the “drag-out” of chemicals from one cleaning stage to the next. Intermediate rinsing can often be done with “soft water” rather than with pure or ultrapure water. The final rinse is usually done with pure or ultrapure water. Pure water is produced by membrane filtering using reverse osmosis. Ultrapure water uses ion exchange columns to lower the ionic content of the water below that achieved by reverse osmosis. Both purification methods use carbon filters to remove organic materials and mechanical filters to remove particulates. One key to effective rinsing is to use copious amounts of rinse water. This means that some method of recycling of the rinse water may be desirable.

In some cases the final rinse may contain a material that inhibits recontamination after cleaning. For example, a “flash-rust inhibitor” may be used to prevent rusting of mild steel after the alkaline cleaning operation which removes oxide surface layers. This protective material may be removed in the PVD deposition chamber by in situ cleaning. The final rinse fluid may be a material that has a surface tension less than pure water such as a water-alcohol mix (1:1) or a drying solution. These materials can penetrate into “hideouts” better than water to displace cleaning fluids. These low surface tension fluids can be “blown off” more easily in the drying stage. If the rinse fluid has a high vapor pressure this will also aid in drying.

Ultrasonic agitation can be used in any of the fluid tanks. Ultrasonic power should be about 100 watts per gallon of fluid. For some materials, care must be taken when using ultrasonic cavitation because prolonged high-power cavitation can fracture the surface.

Figure 1. Typical tank-type cleaning line for parts mounted on a rack.
of brittle materials and deform, erode and microroughen the surface of ductile materials. These surface features can then affect film growth, properties, and adhesion.

When the cleaning requirements are very stringent it may be desirable to use “cascade” or “counterflow” rinsing. Figure 2 shows a cascade rinse tank arrangement where there are three rinse tanks with increasing water purity. The parts move from the lowest-purity to the highest-purity tank. The water between each stage is filtered. The condition of the water in each tank is monitored by measuring the ionic conductivity. The conductivity in the tank is controlled by the flow of water from the previous tank and the amount of pure or ultrapure “make-up” water used. It should be realized that the conductivity measurements do not indicate the presence of organic or particulate contaminants that can build up in the system if they are not removed by filtering.

The final step in the cleaning line is drying, which ensures that there is no significant amount of residue left on the surface. Water tends to dry by “puddling-up” which gives local contamination (“water spots”). In the cleaning line shown, drying is achieved by blow-off with hot air to remove as much water as possible, along with mechanical movement of the parts to promote draining. The parts can be further dried on their way to the storage or deposition area through a low-humidity, warm drying tunnel. Drying can also be done using an enclosed vapor dryer. Vapor drying is particularly useful when there are hideouts that retain water by capillary action.

After drying, the cleaned parts should be stored and transported in a manner that does not allow undue recontamination of the parts. This can best be done by incorporating the cleaning line into an in-line deposition system. This is commonly done in coating mirrors and architectural glass panels.

Often the final cleaning of the substrate surface is done in the deposition chamber (in situ cleaning). In situ cleaning can include: sputter cleaning, plasma cleaning, reactive plasma cleaning, and/or heating.

**Reference**