Precision drying: a critical step in wet process cleaning

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Cleaning, an integral part of many manufacturing and maintenance processes, is often critical to the performance of a broad range of technologies in industries such as biotechnology, defence and semiconductor.

In this article, cleaning refers to:

- the use of agents such as solvents, acids or bases to remove unwanted particulates and other contaminates from products ranging from optics to semiconductor and electronic devices; and
- the etching process utilised in semiconductor fabrication for precision removal of thin layers of material.

In both cases, the wet process cleaning involved usually incorporates the chemical cleaning agents, an appropriate rinse bath and a method of drying the material.

However, while attention is typically focused on the chemicals used, along with time, temperature and agitation, matching precision drying to the cleaning process and even customising it is an essential element that must also be considered.

Selecting a drying process

There are many types of drying that can be incorporated into the cleaning process, depending on the goal.

Consideration must be given to the key objectives in the drying process. This could be the final cleanliness of the surface and achieving low residual particle counts, drying time or a combination of both. The drying should be geared towards being most effective based on these objectives.

Although convection drying, N2 blow off drying and HEPA filtered blow off drying are sufficient for many applications, they may not be the best options if low particle counts are important.

Convection drying involves the drying chamber being heated to evaporate the water off the product, and hot, filtered nitrogen or clean dry air can assist the drying. This can leave behind residue and water spots as the water evaporates. Also, depending on the volume of water, evaporation can take a long time. Although the process is low cost, it is not suitable if a clean dry is required or when products are temperature sensitive.

N2 blow off drying involves nitrogen being blown into the drying chamber through high-pressure air knives. The moisture is blown off the product and down into the plenum where it is evacuated in the exhaust stream. Although the process is initially lower in cost, it uses a lot of nitrogen, may not totally dry product and does not work with geometries that retain moisture, particularly those that have blind holes.

HEPA filtered blow off drying involves hot clean air being blown through a HEPA filter and into the drying chamber where it evaporates the moisture. Again, although the cost of the process is low, it may not totally dry the product and does not work well with moisture retaining geometries.

To leave the least amount of particles—such as on silicon wafers, glass substrates, disc drives or optics—either a surface tension gradient (STG) dryer or a closed-loop vapour (CLV) vacuum dryer is recommended.

In a STG dryer, the chamber is filled with water and then isopropyl alcohol (IPA) vapour is slowly introduced into the chamber as the water is removed, replacing the water with IPA. The IPA is then evaporated. This process has several advantages, namely it uses relatively little IPA, it is environmentally friendly in terms of having low IPA emissions, and there is no water spotting and no moving parts to generate particles. However, one disadvantage is that a large amount of deionised water is used for rinsing.

In a CLV vacuum dryer, ultra-clean IPA vapour is generated and then introduced into a sealed drying chamber. The closed-loop system allows fresh IPA vapour to rinse the surface to be dried, penetrating the surface areas and absorbing the moisture. A low-pressure vacuum pulls any remaining moisture from the sealed chamber and away from the product being dried. This process has a number of advantages, namely it affords the cleanest dry since there is no water spotting and no moving parts to generate particles, blind holes are also dried, and it is environmentally friendly in terms of having low IPA emissions.

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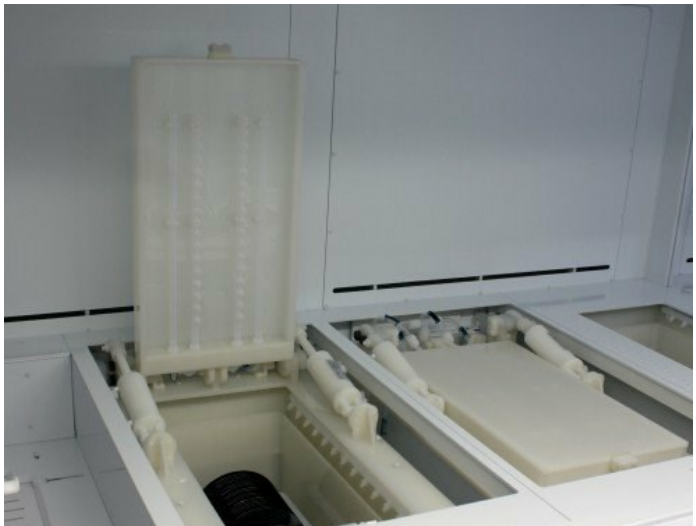



Taking into account the geometry and features of the product

As well as selecting the most suitable drying process, it is important to look at the geometry and features of the product being dried in order to optimise the entire procedure. The handling of non-standard items of various geometries, sizes and weights is often not taken into consideration.

When a product is removed from a chemical bath, it will carry some moisture with it. Round-shaped products clean more easily than flat-shaped ones, which are more prone to hold onto moisture when removed. This is because if the product is round-shaped, moisture is likely to roll off the surface, but if it is flat-shaped, i.e. level, moisture tends to be retained on the surface. Therefore, a product's geometry and how it is removed will dictate in what ways the drying equipment should be optimised.

This is also the case if a product has blind holes that are drilled, bored or cast to a specific depth. When a product with many holes is removed from a chemical bath, those holes can retain a lot of moisture, so it is advisable to rotate the item to dump out the chemical and/or rinse water prior to drying.

In both of the aforementioned instances, vacuum or oven drying is required.

Paying attention to the carrier rack or fixture for the parts is also important to ensure no excess water is retained. It is no good drying the part thoroughly, only to leave the carrier rack wet. One should consider how both the features of the product and the rack affect the drying process.

Even the construction of the rack is important because materials such as Teflon are porous and hold moisture. It is better to use a rack that has a non-porous construction because it releases water quickly.

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