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Dry Cleaning Technology

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As a review of wafer cleaning mechanisms in Semiconductor Note 15. indicates, an alternative to the standard wet cleans using liquid chemicals and deionized water is a dry cleaning technology. In this case removal of contaminant from the surface takes place via chemical reaction in the gas-phase converting it into a volatile compound, or as a result of momentum transfer between specie impinging on the surface, or as a result of surface irradiation (IR–heating, UV–bond breaking/oxidation) sufficient to overcome forces causing volatile contaminant to adhere to the surface. The table shows examples of dry cleaning methods that were explored in various cleaning applications.

Possible dry cleaning methods

Particles	Organics	Metals	Nat./Chem.
•Cryogenic aerosol Ar/N_2 •Laser •CO_2 snow	•O_2/Air anneal •Ozone •UV/ozone UV/ O_2 •Remote plasma O_2	•Anneal in Cl-based chem. •UV/Cl_2 or $UV/SiCl_4$ or UV/HCl •Remote plasma HCl •Metallorganic chelation	•Ar sputter •H_2 anneal •Remote plasma H_2 •Remote plasma NF_3/H_2 •AHF/H_2O •AHF/alcoholic solvent •$UV/F_2/H_2$

Gas-phase cleaning methods lack a shear chemical and physical strength of liquid cleaning ambient and as such are not as effective as wet cleans. Specifically, the removal of ultra-small particles in the dry ambient continues to be a challenge. Also, dry cleans are not able to meet the critical metal requirements in high-end Si technology. Furthermore, dry cleans are entirely ineffective in the processing of excessively contaminated wafers such as those following CMP. On the positive side, gas-phase surface processing methods are fully capable of controlling organic contamination of semiconductor surfaces. One important application in this regard is the removal of organic contaminants accumulated on the surface during wafer storage and handling (see for instance SN- 2).

In light of the above, and in spite of potential cost and environmental advantages in cleaning applications over their wet counterparts, the gas-phases methods are used primarily to perform surface “conditioning” (see SN-19) functions rather than strictly defined surface “cleaning” functions.

In summary, the dry surface treatments benefit process the most when applied as an integrated last operation before subsequent critical deposition step. Typically, it takes place in combination with preceding wet cleaning step performed *ex situ* prior to lading wafers to the cluster tool.