

## Cleaning in Semiconductor Manufacturing

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During device processing it is virtually impossible to shield the wafer from contaminants commonly encountered in process environment (see SN-14 “*Contaminants in Semiconductor Manufacturing*”). Unless removed from the wafer surface using dedicated cleaning operations these contaminants will cause defect formation and device failure. As a result, essentially after every pattern definition process and before any subsequent deposition/thermal steps in the device manufacturing sequence, processed wafers are subjected to very thorough cleaning.

Using silicon as an example the process of cleaning in semiconductor device manufacturing, i.e. process which should produce chemically clean surface, can be defined as:

A sequence of operations which remove from the wafer surface (i) any element other than silicon that did reach wafer surface in an uncontrolled fashion, (ii) any molecule, and (iii) particle of any kind.

Cleaning action can be implemented via four different mechanisms. First is a chemical reaction between reactant in the cleaning ambient and contaminant on the surface (Fig. 1a). Second involves physical interaction between cleaning ambient and the surface (Fig. 2b). Third, relies on the momentum transfer between high kinetic energy specie directed toward the surface and the contaminant (Fig. 1c). Fourth, uses radiation (e.g. infrared or UV) to cause desorption of contaminant from the surface.

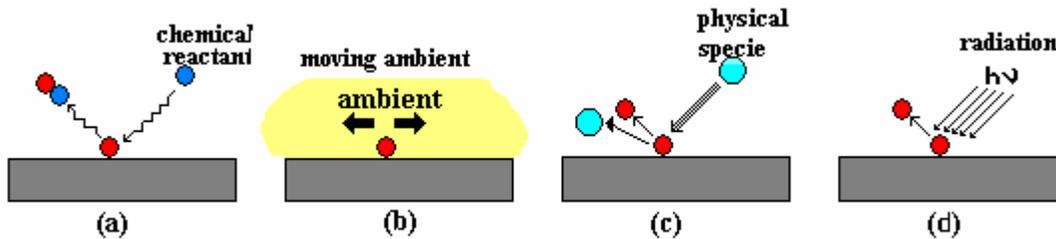


Fig. 1

In practice, cleaning methods are differentiated based on the ambient in which cleaning action is implemented.

In **Wet Cleaning**, contaminant is removed via selective chemical reaction in the liquid-phase (Fig. 1a) which causes either its dissolution in the solvent, or its conversion into the soluble compound. Typically, process is enhanced by physical interaction with an ambient (Fig.1b) such as megasonic agitation, or, in extreme cases, scrubbing with the soft brush (see SN-16 “*Wet Cleaning Technology*”).

In **Dry Cleaning** contaminant is removed via chemical reaction in the gas-phase converting it into a volatile compound (Fig. 1a), or as a result of momentum transfer between specie impinging on the surface and contaminant (Fig. 1c), or as a results of surface irradiation (IR–heating, UV–bond breaking/oxidation) (Fig. 1d) (see SN-2 “*Lamp Cleaning*”).

In **Supercritical Fluid Cleaning** different type of interactions are responsible for cleaning (see SN-8 “*Supercritical Cleaning*”).

Wet cleaning is a mainstream technique in semiconductor device manufacturing due to its ability to remove all kinds of contaminants and its overall efficiency. Dry cleaning supplements wet cleans in selected applications primarily related to surface conditioning which is aimed at the establishing of the desired chemical composition of the surface. Supercritical cleaning is used primarily in the processing of devices featuring ultra-small geometries.