

Basic concepts of wafer cleaning

1 RCA cleaning process by Kern and Puotinen at RCA in 1970(1960 of development)

1.1 SC-1:standard cleaning 1

NH₄OH-H₂O₂-H₂O(1:1:5 to 1:2:7 at 70 TO 80)

1.2 SC-2:standard cleaning 2

HCL-H₂O₂-H₂O(1:1:6 TO 1:2:8 at 70 to 80)

- Above process are based on hydrogen peroxide
- At a high pH value SC-1 can effectively remove organic contamination and particles by oxidation.
- At a low pH value SC-2 can desorb metal contamination by forming a soluble complex.

Contamination	Possible source	Effects
Particles	Equipment,ambient,gas,deionize water,chemical	Low oxide breakdown Poly-Si and metal bridging inudced low yield
Metal	Equipment,chemical reactive ion etching(RIE), implantation ashing	Low breakdown field Junction leakage Reduced minority lifetime Vshift
Organic	Vapor in room,residue of photoresist,storage container,chemical	Change in oxidation rate
Micro roughness	Initial wafer material,chemical	Low oxide breakdown field Low mobility of carrier
Native oxide	Ambient moisture,DI water rinse	Degraded gate oxide Low quality of epi-layer High contact resistance Poor silicide formation

Mechanisms for Removing particles and contaminations

1) Particles

1.1 Particle concentration (Number/mL)

	>= 0.2um	>=0.5um
NH ₄ OH	130-240	15-30
H ₂ O ₂	20-100	5-20
HF	0-1	0
HCL	2-7	1-2
H ₂ SO ₄	180-1150	10-80

1.2 Particle adhesion is dominated by several mechanisms:

forces due to static charge on the particle or to van der Waals forces ,forces due to the formation of an electrical double layer,forces due to capillary action around the particle,and a

chemical bond between the particle and the surface.

1.3 Particle removal mechanism can be classified into 4 types.

1.3.1 Dissolution

1.3.2 Oxidizing degradation and dissolution

1.3.3 Liftoff by slight etching of the wafer surface

1.3.4 Electric repulsion between particles and the wafer surface

Metal contamination

-Start at a level of 10^{10} atom/cm²

-Inducing

structural defects at the interface

stacking faults during later oxidation or epitaxial process,

increased leakage current of p-n junction,

minority carrier lifetime

- Two mechanisms for precipitation of metal impurities

1) direct binding to the Si surface by the charge exchange between a metallic ion and hydrogen atom that terminated on the Si substrate.

->not easy to remove in the wet cleaning process ,these metals usually noble metal ions such as Au,whose electronegativity is higher than that of Si and that tend to be neutralized by taking an electron from Si and to precipitate on the Si surface.

2) precipitation of metal impurities occurs when oxide forms on the surface and metallic impurities are included simultaneously. Such as Al,Cr,and Fe tend to oxidize when the Si surface is oxidized and are included in the oxide film.

removed by etching the oxide with dilute HF.

HF-H₂O₂(HF:.5%,H₂O₂:10%)cleaning is effective in removing metallic impurities that bind directly with Si surface.Some additives,such as hydrocarbon-type surfactants,which are added to BHF(buffered HF) to improve its wettability of the Si surface,are also found to be effective in removing Cu at room temperature.

Both SC-1 and SC-2 have the capability of removing metallic impurities on the Si wafer,This is believed to result from the high oxidizing mechanism of the H₂O₂.

Metallic contamination on the surface also induces microroughness