Contact cleaning opportunities on single wafer tool

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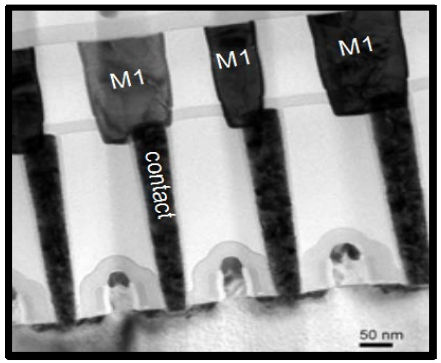
Contact Cleaning overview



500x500 nm²

What was contact cleaning ?

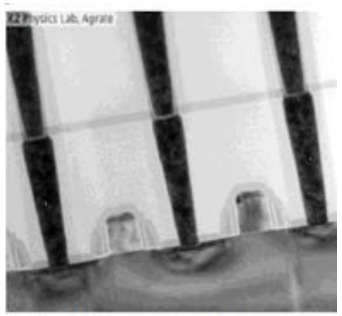
- A « standard » post-etch clean :
  - ❖ Batch sprays and Wet-benches
    - Cleaning process « BEOL like » with EKC solvents
    - Cleaning process « FEOL » with SPM_SC1_SC2
  - ❖ Transfer to Single wafer for defectivity reduction
    - « usual » recipes : SPM_SC1_SC2_Nanosprays
    - New recipes : HF/O3, …
- Almost same clean what ever the silicide CoSi / NiSi

However, a lot of recent evolutions were due to new materials introduction, patterning scheme evolutions, Contact A/R increase

Contact Cleaning Challenges

Cleaning Challenges due to new materials introduction :

- Metal Gate technologies → 28nm FDSOI & Silicide First Architecture
  - → Gate metal etch/corrosion → SPM step removed
  - → **SC1 + HCl only is one alternative**
- Mix of std contact landing on silicide with contact on sensitive materials :
  - → W in stacked CT or W trenches for 14nm technologies
  - → SPM & SC1 steps not compatible with W
  - → **Need to evaluate other solutions**


stacked contact

Drying Challenges :

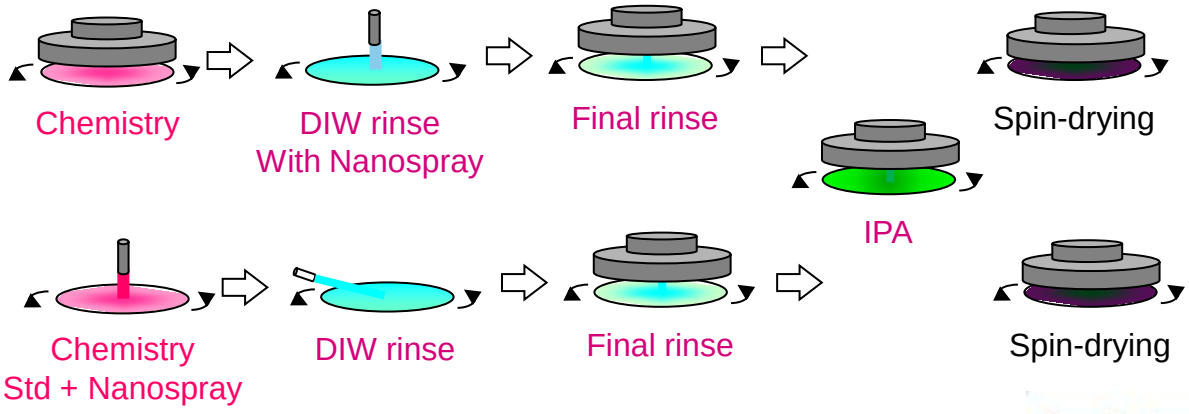
- Contact CD ↘ & Aspect Ratio ↗
- Q-Time management after cleaning
  - → **IPA Drying evaluation**

This work aims to :

- **compare cleaning efficiency, by using a High Yielding technology**
- **Investigate IPA Drying for high aspect ratio contacts**

Experimental _ Tool & Chemistries

- Chemistries & recipes
  - Reference clean : SPM _ SC1 _ SC1NS*, std spin Dry
  - “SC1” : SC1_SC1NS_HCl : std spin Dry & IPA Dry
  - “HF02” : dHF (0,2%wt.), DIW rinse with NS*, std spin Dry & IPA Dry
  - “GLYHF” : Mix HF0,025% + Glycolic acid 1% @ 60° C : std spin Dry
- Wet tool & options
  - Single wafer cleaning SU-3100
  - Central dispense + Nanospray for SC1
  - [O2] control over the wafer with Shieldplate @ low position for dHF
  - IPA Dry after SC1 or dHF



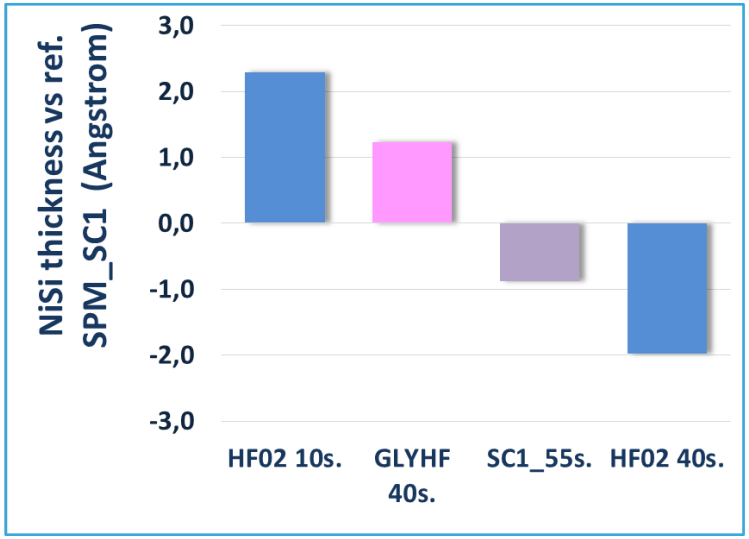
Experimental _ Materials and Technologies

- Wet etch-rate
  - NiSi thin film 25nm thick, measured by ellipsometry
  - SiO2 thin film (PMD stack), measured by ellipsometry (not shown here)
  - TiN, W thin films, measured by 4 point probe resistivity (not shown here)
  - Contact CD variation, measured by SEM_CD

- Technologies & Tests wafers

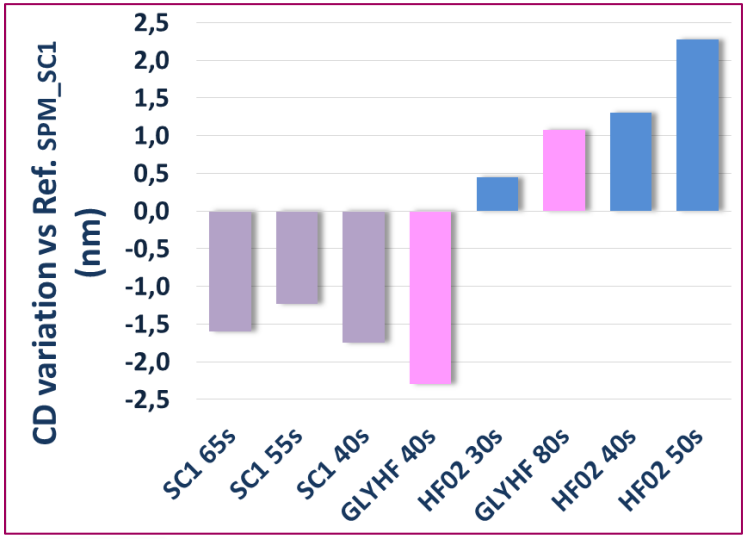
Techno type	Silicide type	Contact CD & A/R	Cleaning Process vs SPM_SC1 reference
C014	NiSi (Pt10%)	40nm	HF0,2%
C028	NiSi (Pt10%)	40nm	HF0,2% / GLYHF / SC1_HCL
C040	NiSi (Pt10%)	55nm max A/R = 7	HF0,2% / GLYHF / SC1_HCL

Results _ NiSi thickness & CD Variations



Silicide thickness variation vs Ref. SPM_SC1 (NiSi)

- ✓ **Range -2 to +2 Å**
- ✓ **Very small variations vs PoR**



Contact CD Variations vs Ref. SPM_SC1 :

- ✓ **Range -2 to +2 nm**
- ✓ SC1 & low HF budget : CD < Ref.
- ✓ HF budget ↗ : CD > Ref. & CD ↗

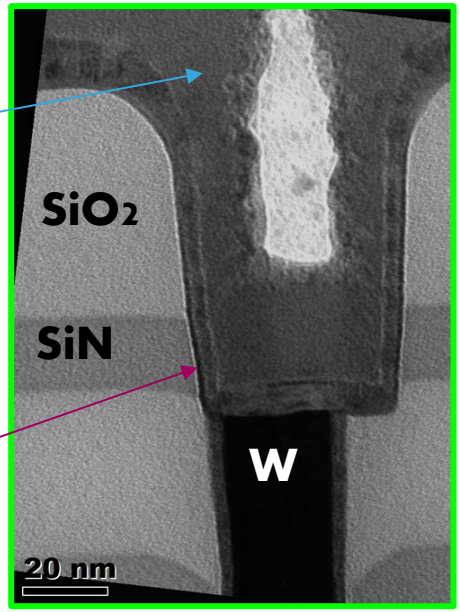
CD variation sensitivity depends on technology node and possible adjustment to be done in Litho & Etch

Preliminary Results with HF0,2%

TEM view of 14nm contact landing on W trench, clean HF02, 50s :

Contact filling for TEM lamella preparation

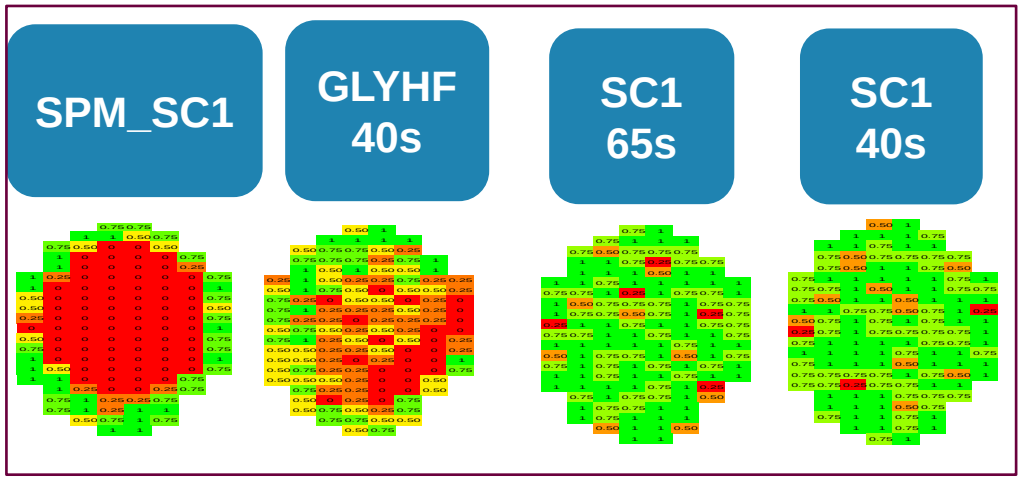
TiN barrier



- ✓ **No Oxide over - etch vs SiN**
- ✓ **No degradation of contact profile**
- ✓ **No over-etch on W trench**

Preliminary Results _ cleaning wo SPM

Example of SRAM Yield mappings for 28nm technology (metal gate)

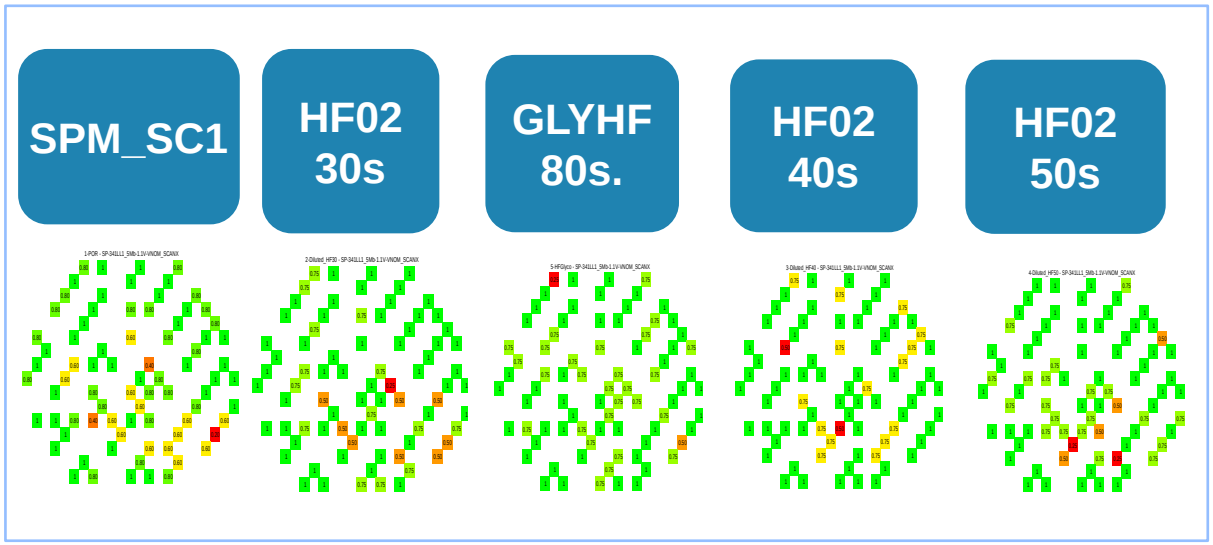


PoR strongly impacted by voids in Metal gate (metal etch by SPM)

- ✓ **SC1 : Best Split**
- ✓ GLYHF 40s. Poor cleaning → Yield loss

Results : Cleaning efficiency comparison on High Yielding Technology (40nm node)

Example of SRAM Yield mappings for 40nm technology



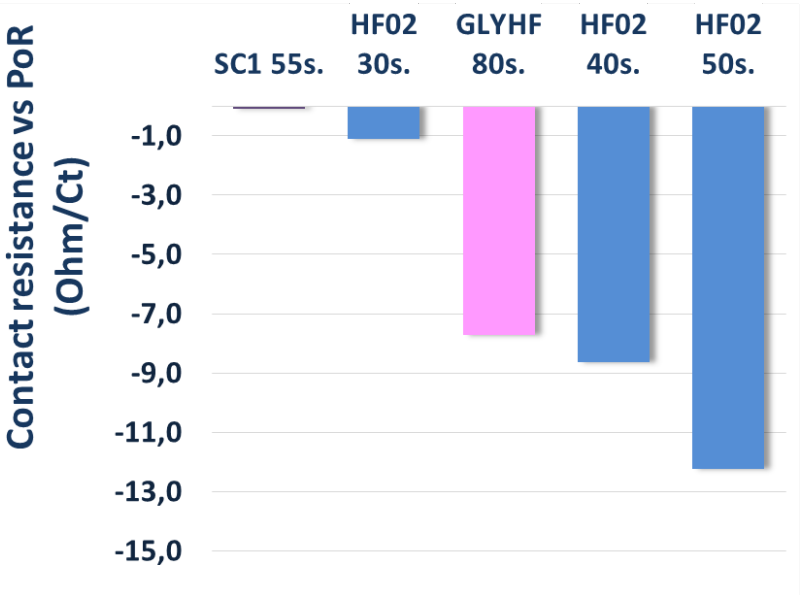
Arbitrary unit for yield
Bad → Good

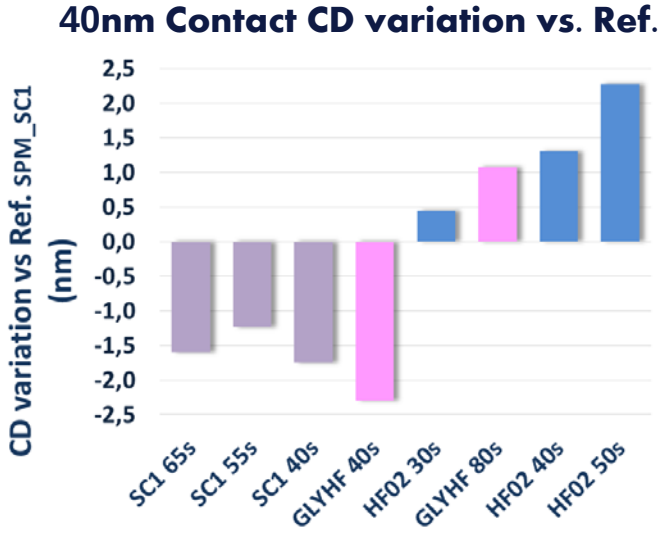
No materials compatibility concerns → Ok for cleaning comparison

- ✓ **HF0,2% : good yields (30 – 50sec. Process)**
- ✓ GLYHF 80s. = better than 40s.

Results : Cleaning efficiency comparison on High Yielding Technology (40nm node)

40nm Contact resistance variation vs. Ref. (Contact on P+ active)





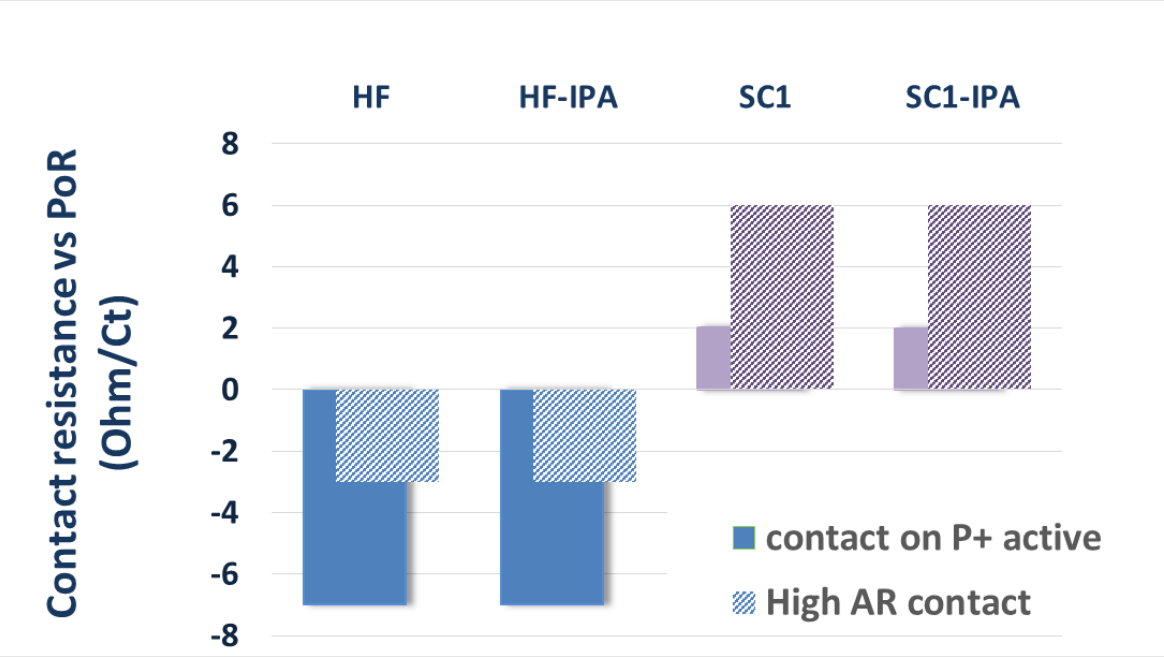
- ✓ **No Resistance increase vs PoR → confirm efficient clean**
- ✓ **SC1 : No CD Loss & Good efficiency (R = same as PoR)**
- ✓ GLYHF & HF02 : Resistance ↘ well correlated to CD ↗

Results : IPA Drying efficiency

40nm Contact resistance variation vs. PoR. Contact std & High A/R contact

NEW Parameters :

- ✓ IPA DRY
- ✓ Contact A/R

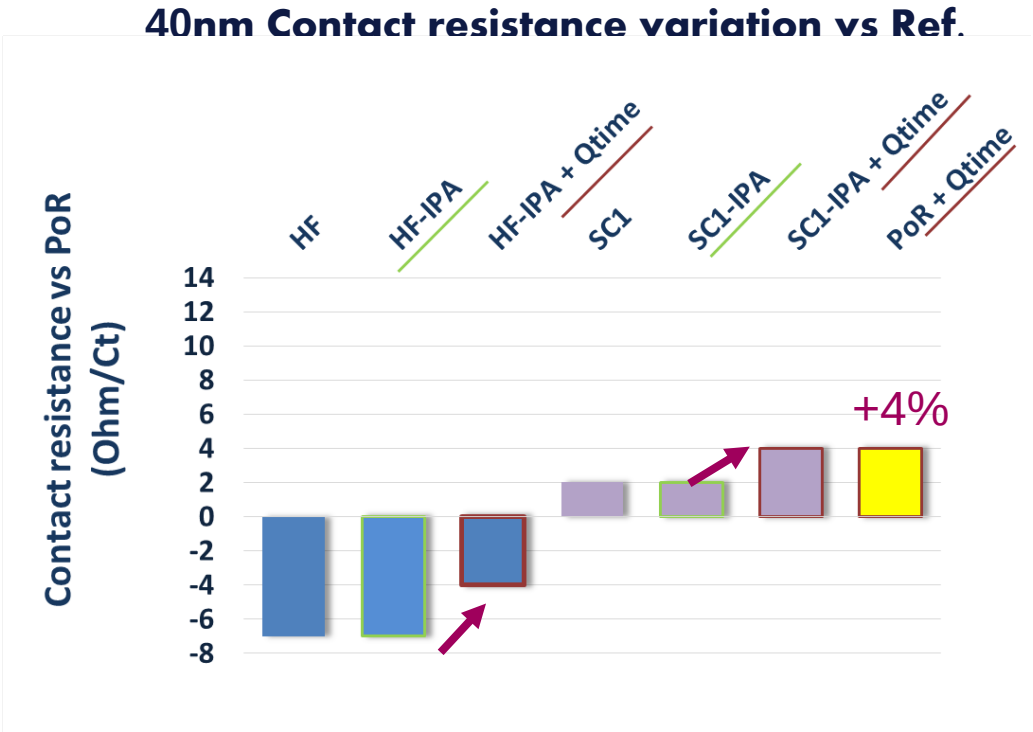


- ✓ No Resistance increase with IPA vs No IPA → No issue
- ✓ IPA dry implementation possible without process degradation

Results : Qtime effect

NEW Parameter :

Qtime WET – TiN barrier dep



- ✓ **No drastic PoR degradation with Qtime (4%) → No clear conclusion**
  (maybe due to physical split effect with few wafers in the Foups)
- ✓ **Slight Resistance increase with Qtime (all wet process), same on high A/R contact**
- ✓ **No specific effect of IPA dry vs Qtime management on this lot**

Conclusion

- Single wafer tool improved cycles of learning for developing new cleaning recipes sequences
- New materials / new integration schemes requires changes in traditional wet cleans
  - SPM is no longer compatible
  - Diluted HF is an effective replacement but consideration is required for CD changes
- IPA drying is compatible although no benefits shown in this work
  - Good candidate for future technology nodes if N2 drying issues arise.

Thank you for your attention.