

Role of mask on the contact etching for 14nm nodes

MEBARKI Mokrane^{1,2,3}

Maxime Darnon², Cecile Jenny¹, Nicolas Posseme³, Delia Ristoiu¹, Germain Servanton¹, Olivier Joubert²

¹ ST Microelectronics

² Laboratoire des technologies de la microélectronique (LTM) CNRS

³ CEA LETI

PESM

Monday, May 12 2014

Grenoble, France



Double patterning for contact etching

- Double patterning strategy

Mask Opening

- Comparison between N_2/H_2 vs CO_2/O_2

Silicon oxide etching

- Interaction with OPL mask opening process

Conclusion

Double patterning for contact etching:

3

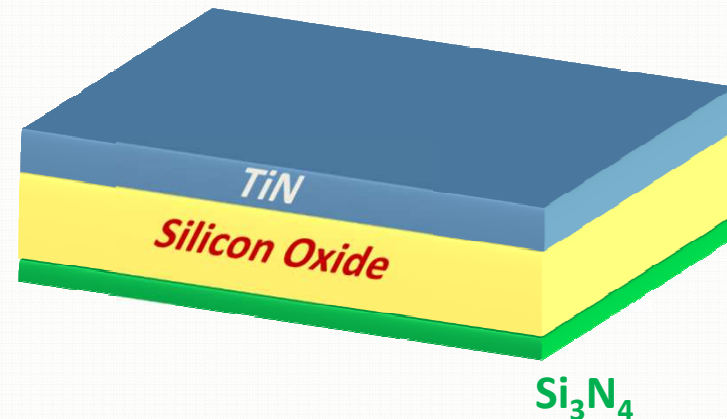
Increase the number of transistors on a chip

Reduce the transistors dimension

Change of contacts patterning strategy

Double patterning

First patterning

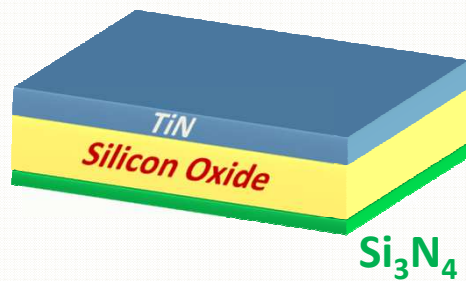


1. TiN deposition

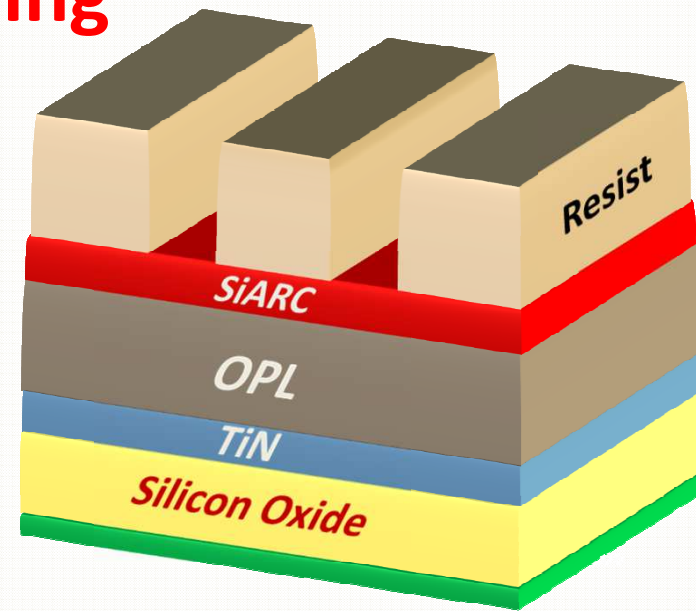
Double patterning for contact etching:



Double patterning First patterning



1. TiN deposition

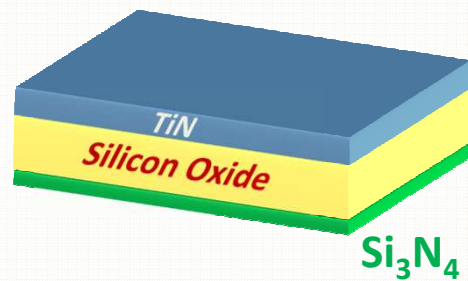


2. Trilayer line pattern

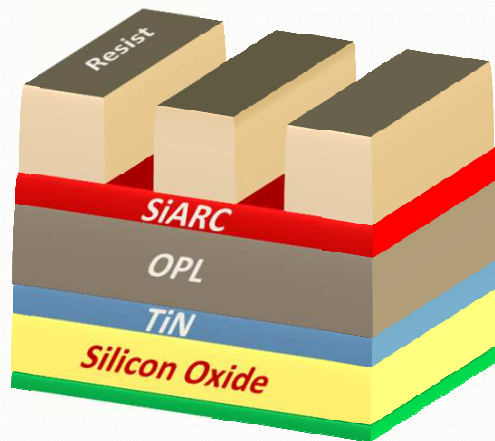
Double patterning for contact etching:



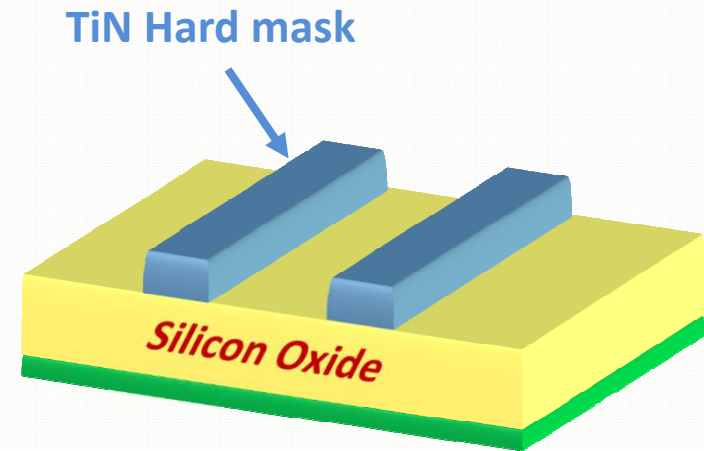
Double patterning First patterning



1. TiN deposition



2. Trilayer line pattern



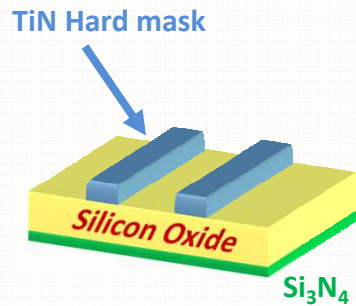
3. Post etching of TiN hard mask

Double patterning for contact etching:

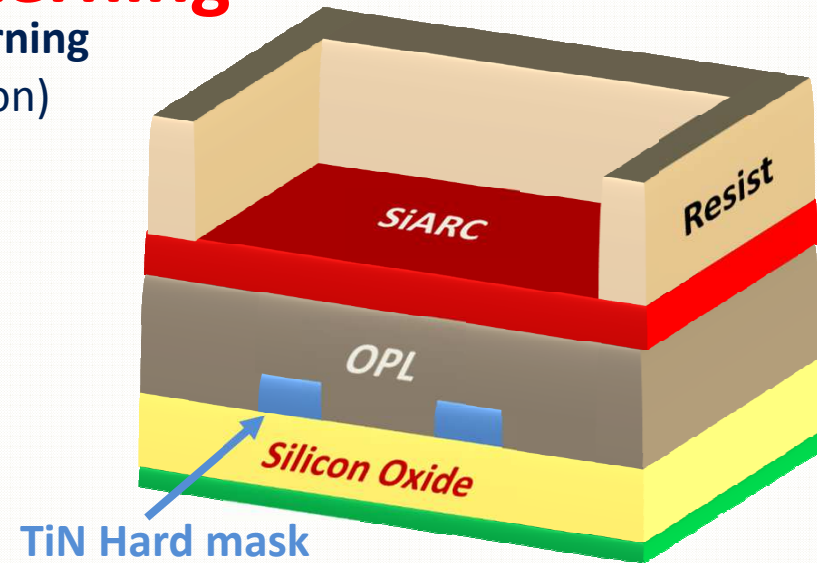


Double patterning

Second patterning
(Cross section)



1. Post etching of TiN hard mask



2. Trilayer OPL mask pattern

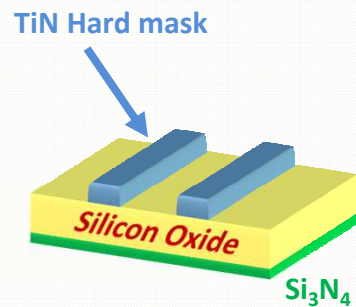
Double patterning for contact etching:



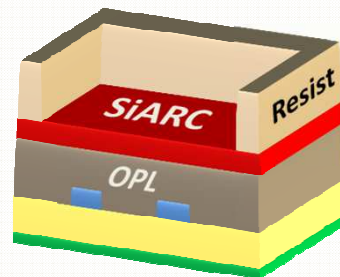
Double patterning

Second patterning

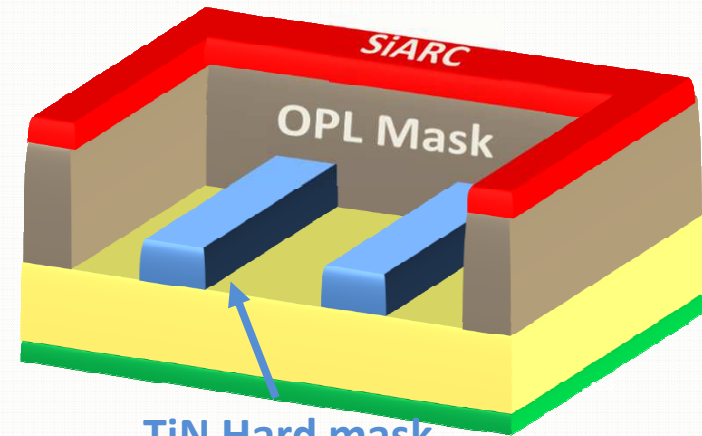
(Cross section)



1. Post etching of TiN hard mask



2. Trilayer OPL mask pattern



TiN Hard mask

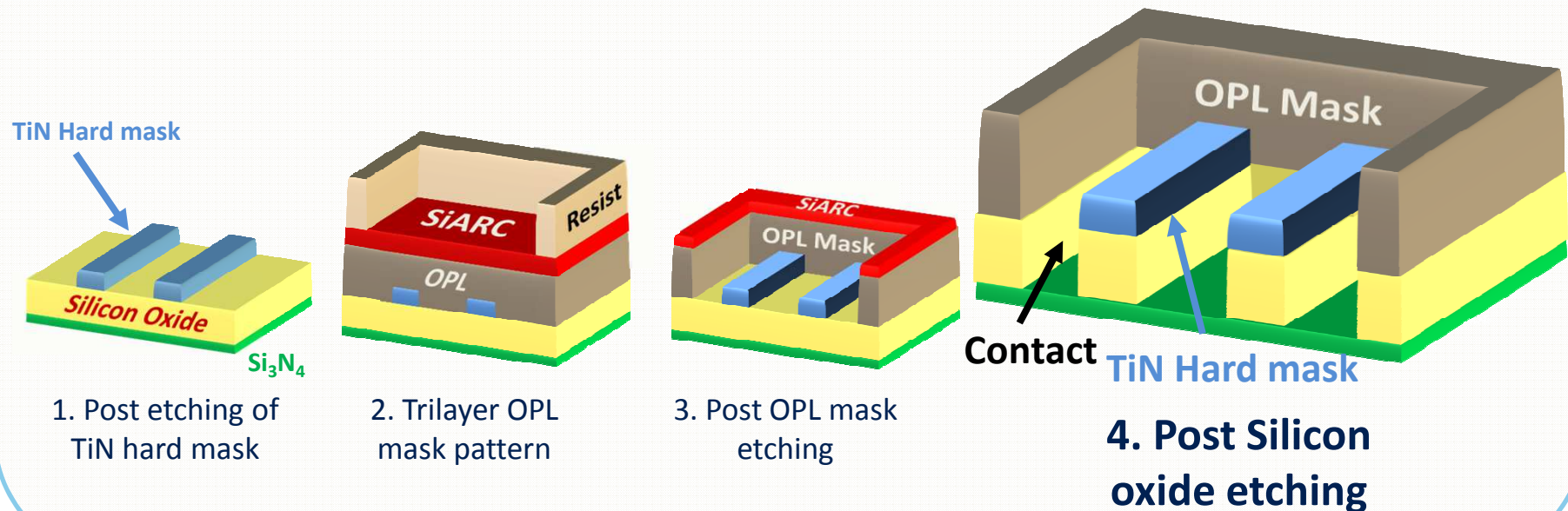
3. Post OPL mask etching

Double patterning for contact etching:

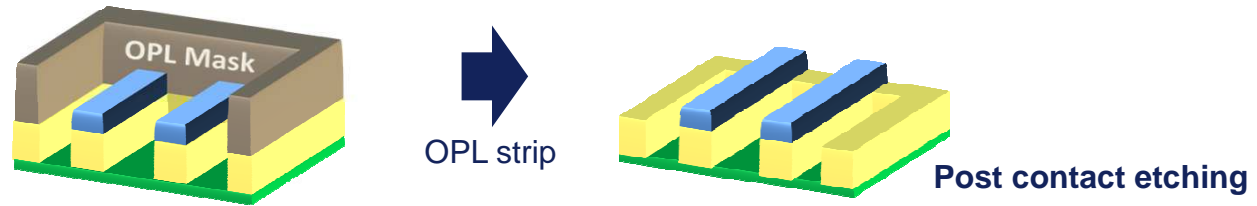


Double patterning

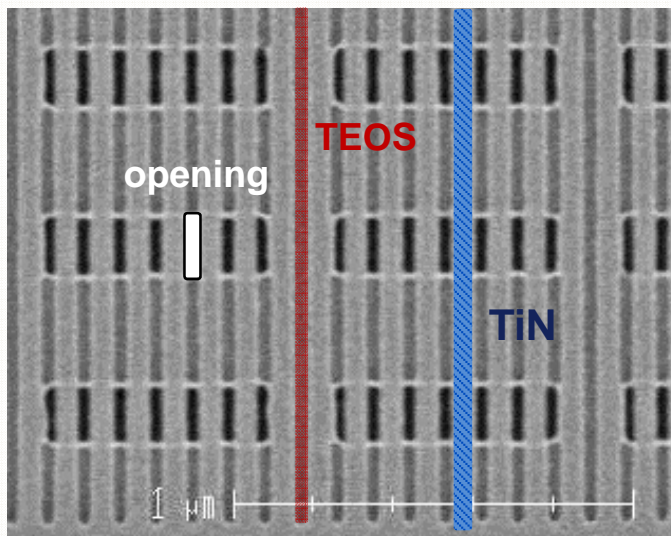
Second patterning
(Cross section)



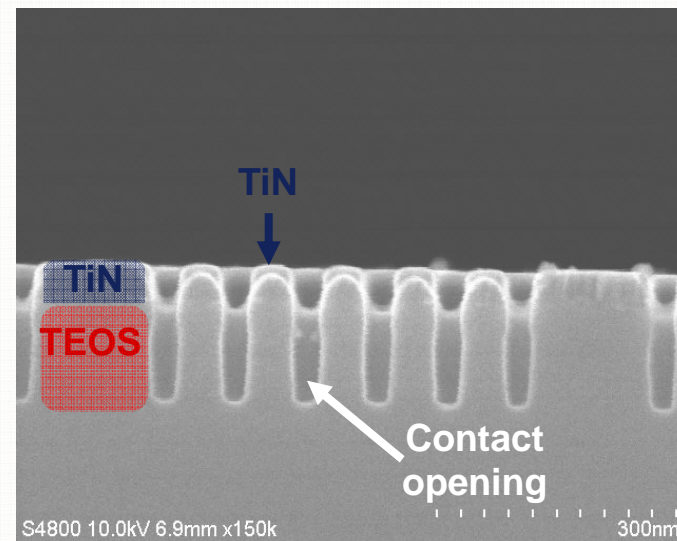
Double patterning for contact etching:



Double patterning



SEM Top view post contact etching



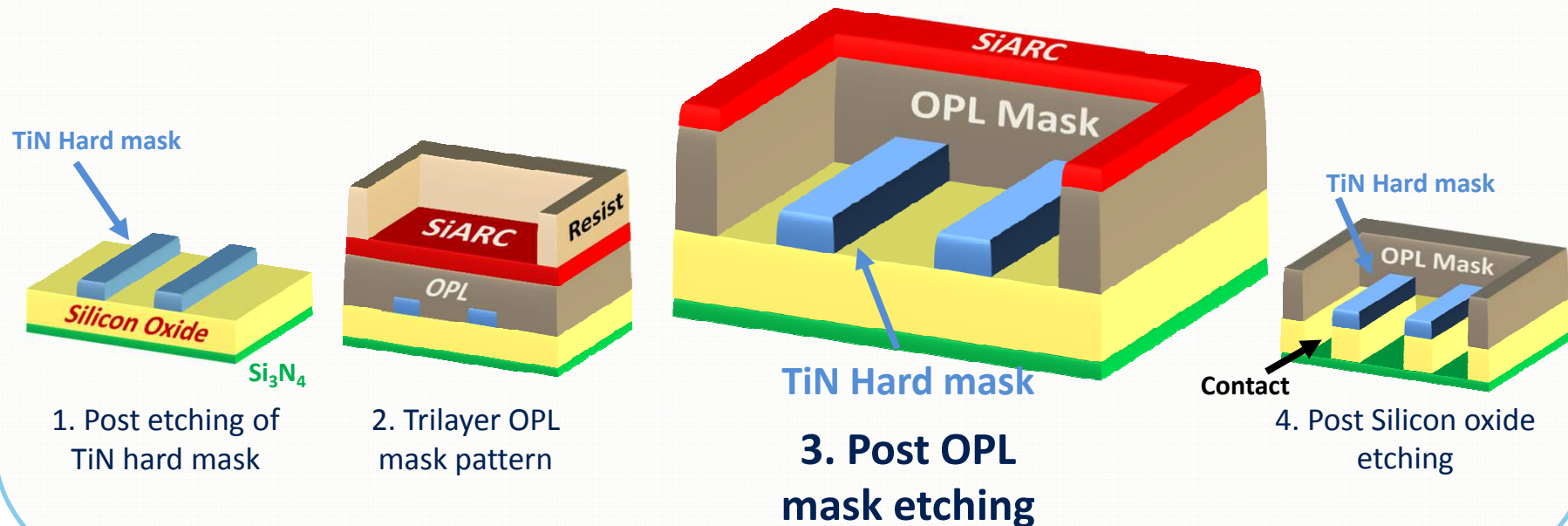
SEM cross section post contact etching

Double patterning for contact etching:



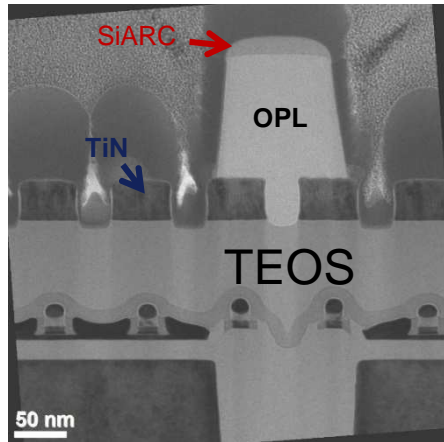
Double patterning

Second patterning
(Cross section)



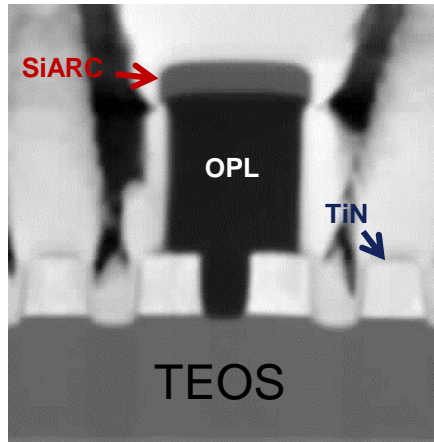
Characteristics of OPL etching:

OPL etching With N_2/H_2

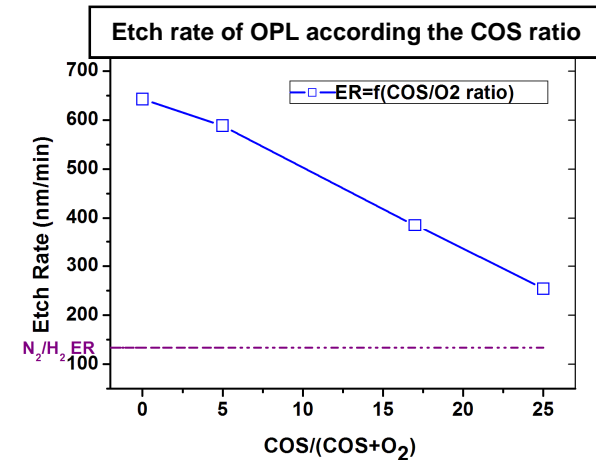


Consumption of SiARC

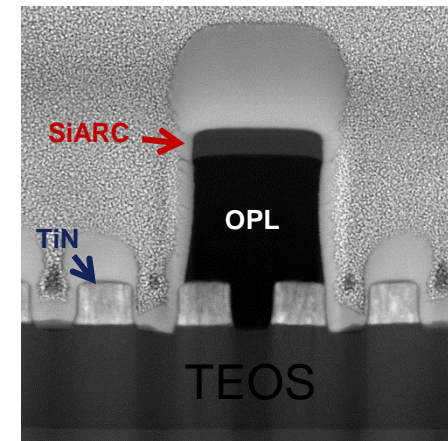
OPL etching With $CO_2/O_2(5\%)$



Presence of undercut on sidewalls of OPL mask



OPL etching With $CO_2/O_2(17\%)$ and shorter over etch

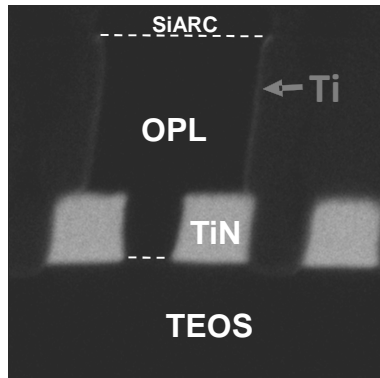
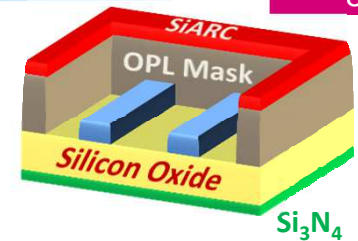


The increase of COS ratio leads a better conservation of OPL mask.

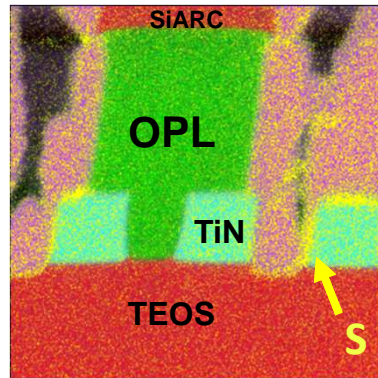
Characteristics of OPL etching:

8

EDX analysis after OPL etching with COS/O_2 (5%) chemistry :



EDX analysis for Ti element

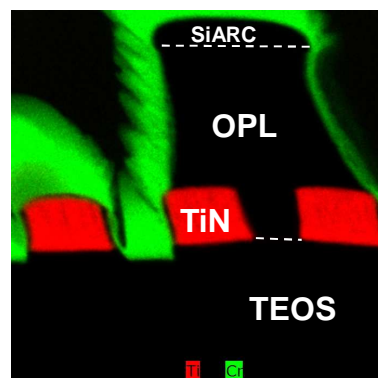
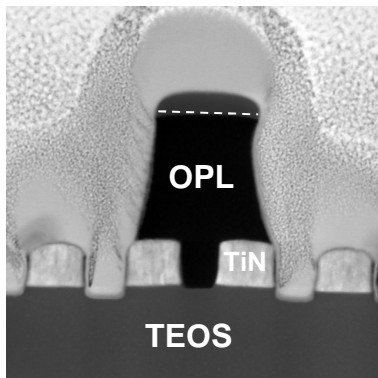


EDX analysis for S element

observation :

- Presence of Ti elements

EDX analysis after OPL etching with N_2/H_2 chemistry :



- No significant TiN sputtering

Interaction between OPL etching and TiN hard mask

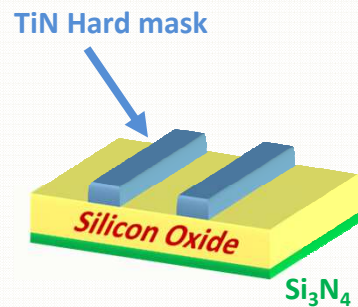
Double patterning for contact etching:



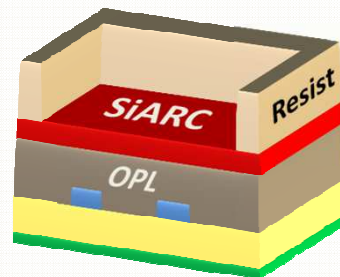
Double patterning

Second patterning

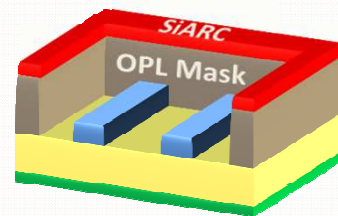
(Cross section)



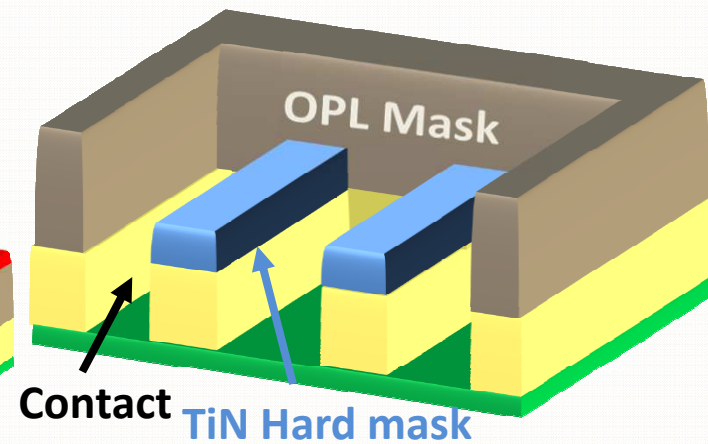
1. Post etching of TiN hard mask



2. Trilayer OPL mask pattern



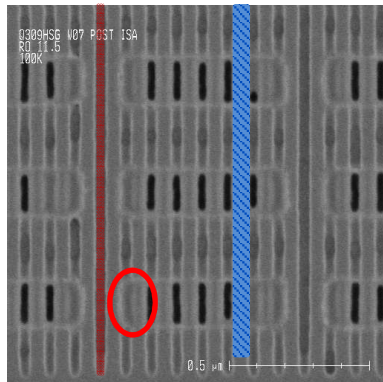
3. Post OPL mask etching



4. Post Silicon oxide etching

Interaction with mask opening process:

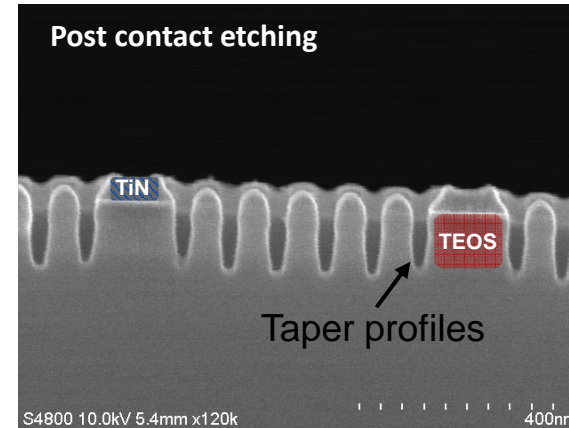
Etch-stop presence after contact etching for the OPL opening with COS/O₂(5%)



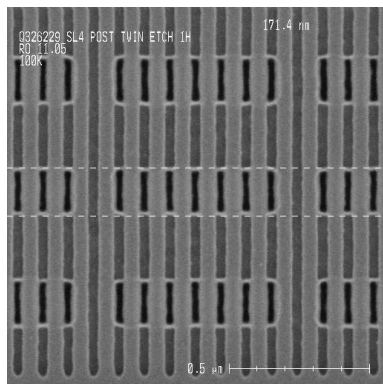
TEOS TiN



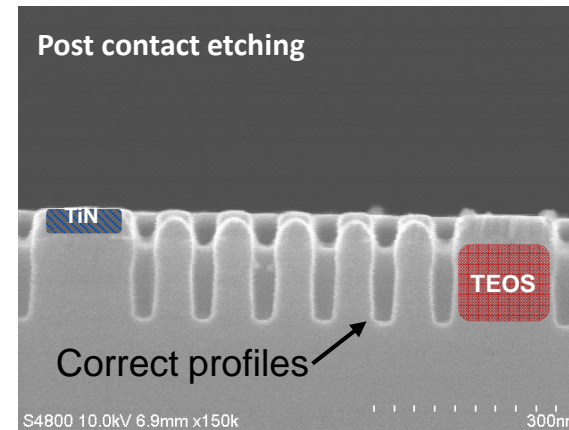
OPL etching with COS/O₂ :



The contacts are open after contact etching for the OPL opening with N₂/H₂

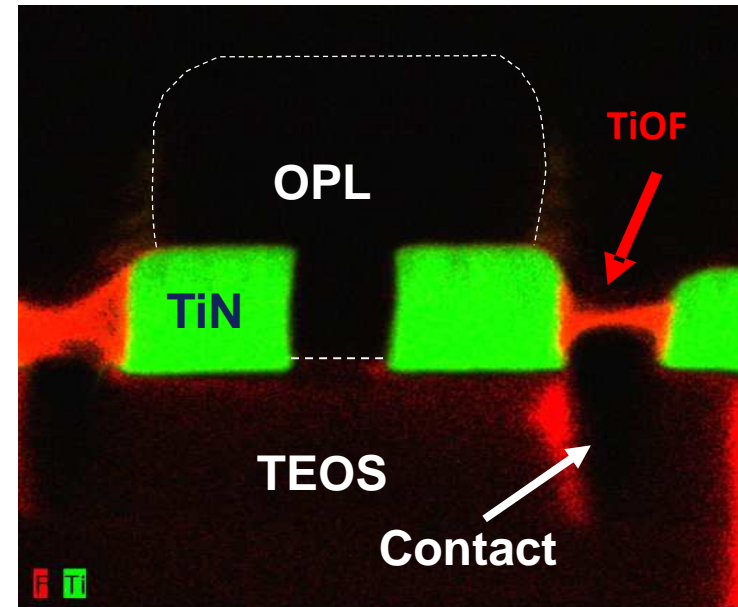
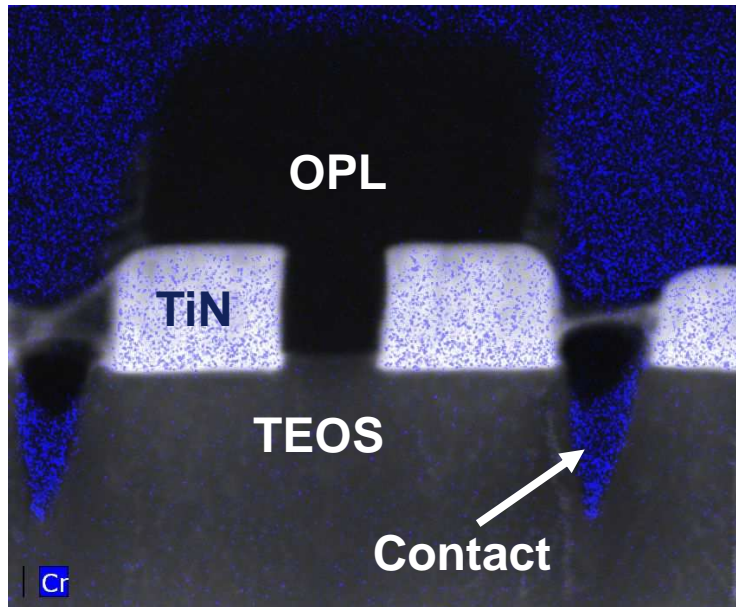
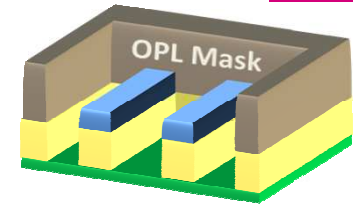


OPL etching with N₂/H₂ :



Interaction with mask opening process:

EDX analysis after oxide etching :

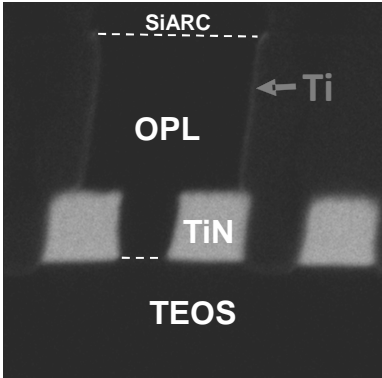


EDX after oxide etching with COS/O₂ (5%) for OPL Opening

Veil formation of TiO_xF_y on the holes patterned

Origin of veil formation:

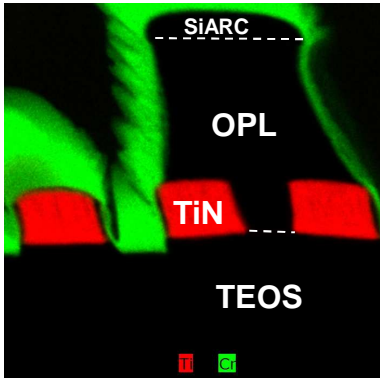
OPL etching with $\text{COS}/\text{O}_2(5\%)$



EDX analysis

TiN sputtering → Ti residue

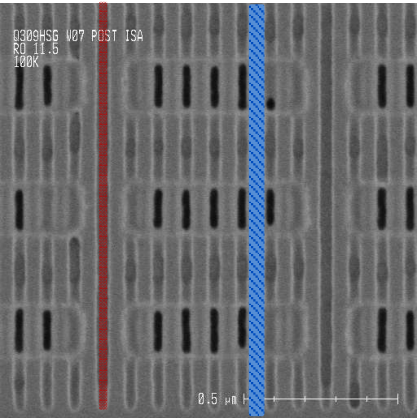
OPL etching with N_2/H_2



No significant TiN sputtering

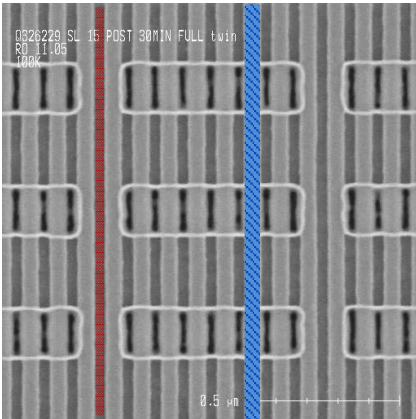
Hypothesis : Ti sputtering during OPL Over Etch induces veil formation during SiO_2 etching

After contact etching for



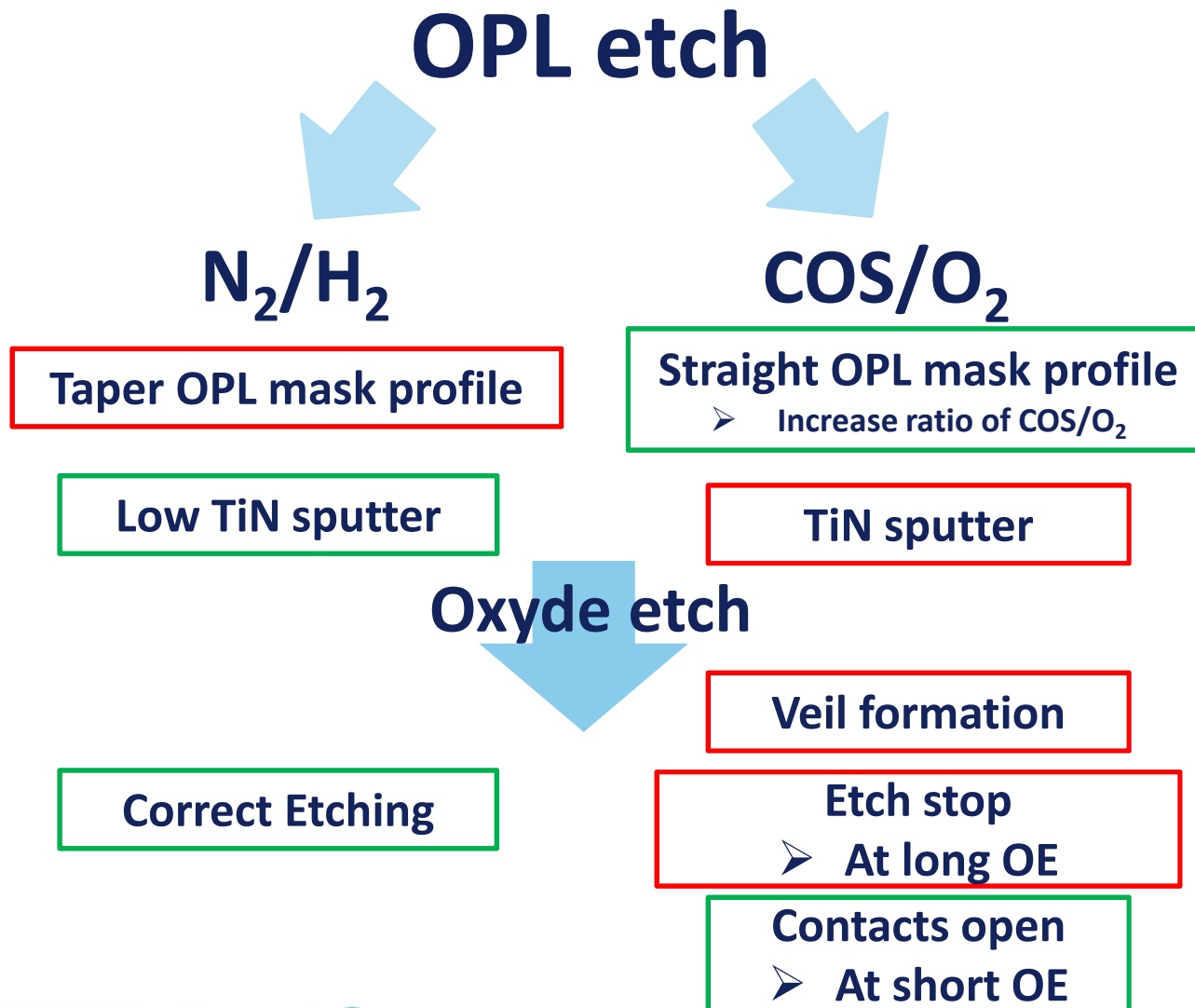
Decrease → time

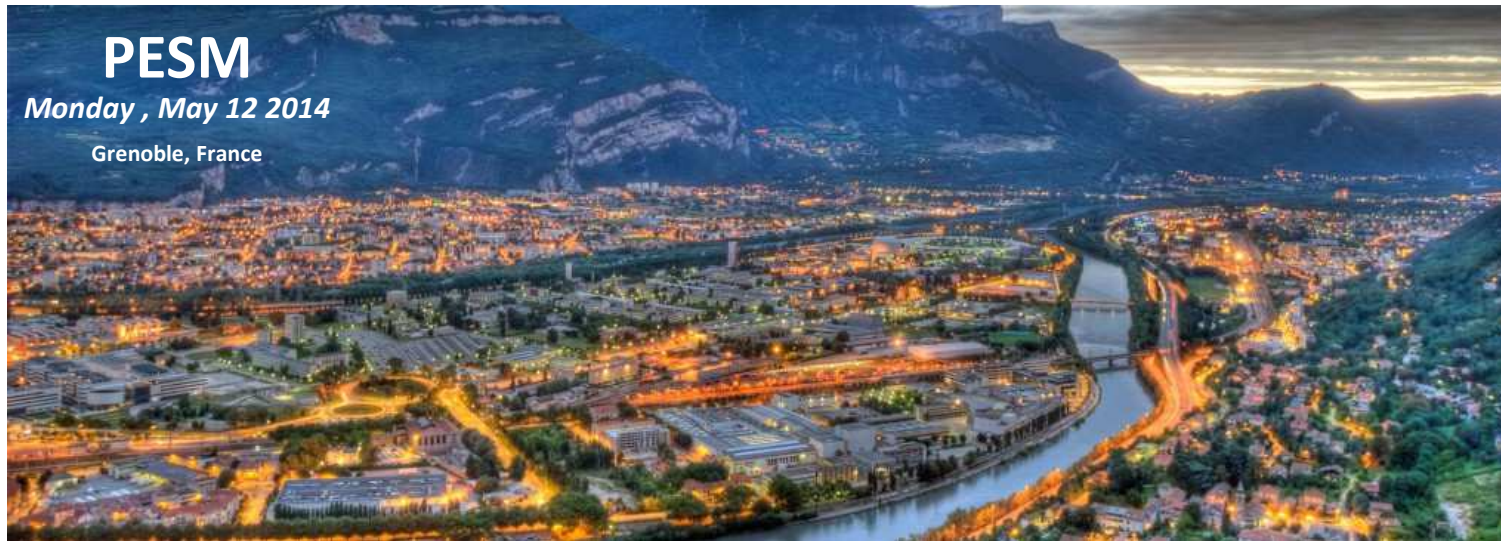
Lower OE → Lower TiN sputtering



No TiOF veil

Conclusion:





Thank you for your attention !



PESM 2014- mokrane.mebarki@st.com