Benefit of post etch treatment for defectivity improvement in the BEOL

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In the challenging context of backend integration, the trench first hard mask architecture demonstrated its interest as the cost efficient solution for volume manufacturing as well as the time effective solution for yield learning. However, one major challenge using such integration is the metal fluoride crystal formation after etching leading to line and via opens.

The mechanism of residue formation is attributed to fluorine species reacting with titanium nitride and being catalyzed by air moisture. More precisely, fluorine and air moisture react to form HF compounds, which react with the TiN to form metallic salts [1].

The impact of the etch chemistry on metal crystal growth as a function of the air exposure time is presented in Fig.1. Important residues are observed only after 2h air exposure when blanket TiN wafer is exposed to high polymerising fluorocarbon chemistry as main or last step. However, when using low polymerising fluorocarbon (FC) chemistry some residues are observed after 8h. This result clearly underlines the impact of the etch chemistry on the metal crystal growth. This is related to important fluorine reduction at the TiN surface (-35%) when using low FC chemsitry compared to high FC chemistry (XPS analyses).

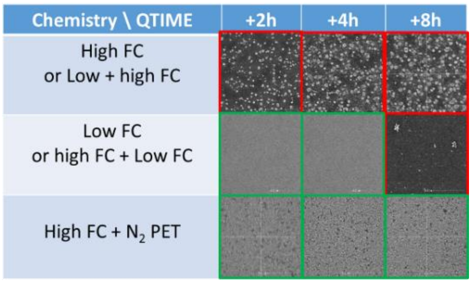

Fig. 1 : TiN surface observation by CD SEM after exposure to different etch chemistries/combination and N_2 Post etch treatment

Fig. 1 also shows that N_2 PET addition after high polymerising chemistry strongly reduces the formation of residues as a function of air exposure time. No residues are observed after 8h air exposure. This result is confirmed with XPS analyses showing that N_2 PET reduces the fluorine concentration from 31% to 25% at the TiN surface. The N_2 PET impact on TiN surface is to reduce fluorine at the surface limiting the reaction (F + air moisture) responsible of metal crystals formation.

Therefore, the choice of the last etch chemistry step seen by the metal hard mask is key to limit metal crystal formation. The use of a low polymerising chemistry as last step is strongly recommanded. Adding an in-situ post etch treatment like N_2, after etching, is essential too. It helps to reduce the fluorine concentration at the TiN surface (and therefore reduce the risk of metal crystal) but we will also demonstrate that N_2 PET is mandatory to passivate the copper surface avoiding other kind of defectivity like copper extrusion.

References

[1] N.Posseme et al., “Residue growth on metallic-hard mask after dielectric etching in fluorocarbon-based plasmas. I. Mechanisms”, JVST B Volume 28, Issue 4, pp: 809 – 816 July-August 2010.