Selective removal of ashed Spin-on Glass

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The abstract described a formulation could remove the ashed SOG quickly and compatible for TiN, TaN, and Al-contained work-function metal.

Spin-on glass (SOG) have been wildly use in semiconductor industry. In the application of Front-End of Line (FEOL) integration, the SOG layer would remove ultimately without damaging the exposed metal gate materials metals such as TiN and TaN and work-function metals which may contain Al, for example, TiAlN and TaAlN.

SOG composition is a liquid, silica-based composition and became porous after ashed by oxygen. Ashed SOG could be removed quickly by fluoride at low temperature. Our formulation shown an etch rate (ER) of 900 A/min for ahsed SOG at 35°C. However, fluoride would attack TiN, thus TiN inhibitors were screened to reduce TiN loss. Two inhibitors were found to be efficient on TiN. On the other hand, we observed that pH (TMAH%) of solution also played an important role on TiN ER. As shown in Fig. 1, TiN ER could be lower than 0.5 A/min with 25% TMAH > 4.5% in formulation. Higher pH (TMAH%) shown lower TiN loss, however, higher pH would cause SOG ER drop.

Since we did not have the film of Al-contain work-function metal, the screening was use Al film as indicator for the actual film. It's found that the TiN inhibitors shown no effect on protecting Al thus additional inhibitor for Al was needed. The screening result was shown in Fig. 2 and inhibitor D was effective to reduce Al loss. In addition, from the data of time split tests, as shown in Fig. 3, where Al loss (measured by XRF) in different reaction time were similar and close to the thickness of native aluminum oxide. Thus we assumed that AlOx would be etched away by fluoride in very short time but the inhibitor will protect Al layer being not damaged.

Besides, the formulation was semi-aqueous based, solvent also plays a role on the metal protection. The influence of solvent on TiN ER was not remarkable while on Al was completely different. Al loss was very sensitive to solvent. Among all the solvents had tried, Al inhibitor D only effective in solvent 1 while in other solvents Al would be etched continuously without stopping. As illustrated in Fig 4, 5-30% solvent 1 was replaced by solvent 2 or 3, the Al loss was increased with the replaced % and became fast in the case of using solvent 3.

In summary, a formulation for fast SOG removal and compatible to TiN, TaN and Al-contained work-function metal was developed. Besides, AlOx could be etched away and keep the Al layer.

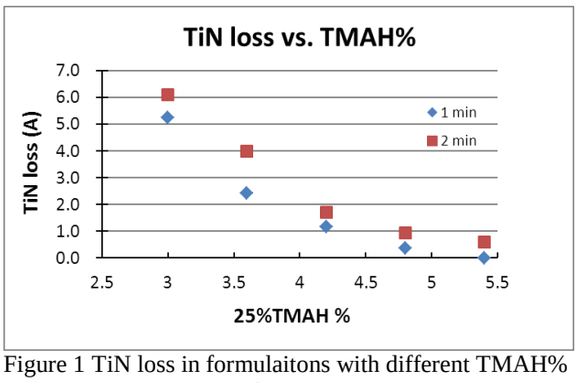

Figure 1 TiN loss in formulaitons with different TMAH% (pH) with reaction time of 1 and 2 mins.

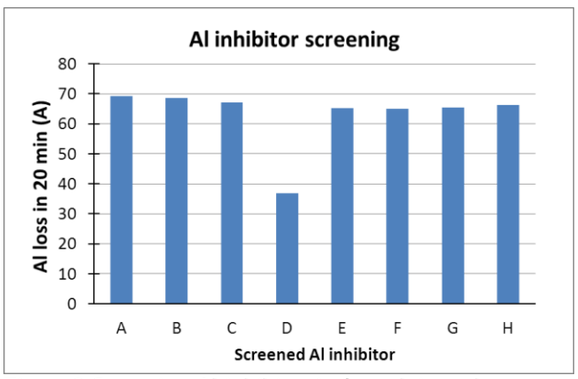

Figure 2 Screening Al inhibitor in formulaiton, the percentage of the inhibitors used here was 0.5-1%.

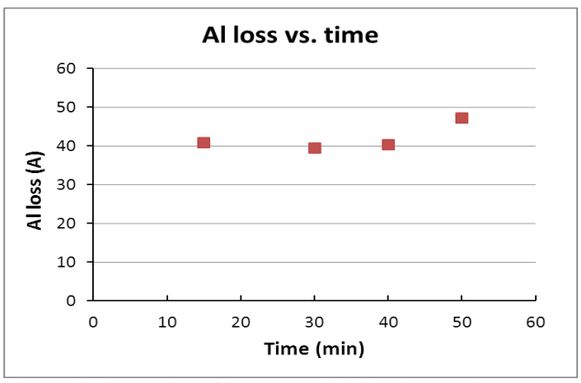

Figure 3 Time-split Al loss test, 15-50 min reaction shown similar Al loss close to AlOx thickness.

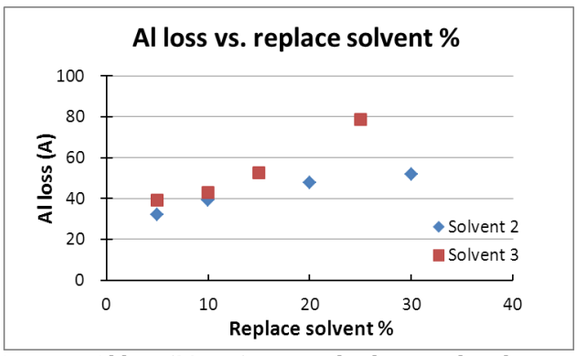

Figure 4 Al loss (30 min) in partial solvent replaced formulaitons. Al loss was increased with replaced percentage.