Developing Wet Cleans for a Cobalt Contact Integration Scheme

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Abstract – Due to ever shrinking dimensions at advanced technology node and the use of FinFET devices, the contact resistance has gone up significantly. There are various resistance contributions that impact device performance, such as contact resistance, silicide resistance, schottky barrier height, etc. (Figure 1[1]). Efforts are underway to reduce these resistance(s). In this paper, we will detail our wet clean process development for one of the potential approaches to reduce contact resistance (by changing the contact fill metal from W to lower resistance metal, Co).

Apart from forming silicides, Co has not been widely used in advanced technology nodes. This requires development of new wet cleans for Co contact integration. In the Cobalt integration scheme, both W and Co are simultaneously exposed during the post etch residue removal step. The ideal clean for this step needs to remove all the post-etch residue and not attack the exposed W and Co metals, while keeping the contact dimensions unchanged.

This proved to be a problem because all of the existing middle of line (MOL) wet cleans were unable to meet all of the ideal clean conditions simultaneously. Review of the Pourbaix diagrams for W and Co revealed a common passivation area in highly reducing conditions with no oxidizer present (Figure 2). These highly reducing, no oxidizer conditions are difficult to create. Even if these conditions were created and maintained, complete removal of the mixed metal-organic post-etch residue would be slow and/or incomplete. Fig. 2 shows that in strongly acidic solutions, W is passivated and Co dissolves. W and Co both dissolve in weakly acidic and neutral solutions. W dissolves in alkaline pHs while Co is passivated in alkaline pHs. Therefore, one cannot perform W post etch residue removal wet cleans without attacking Co.

To summarize, the problem is that thermodynamically and kinetically there is no wet clean that can be used when W and Co are simultaneously exposed at the bottom of the contact. Without developing a new wet clean for this step, one will have high contact resistance and defeat the motivation of integrating a Co contact.

This paper will detail how this wet clean was developed.

REFERENCES:

1) Kelin Kuhn IEDM 2008

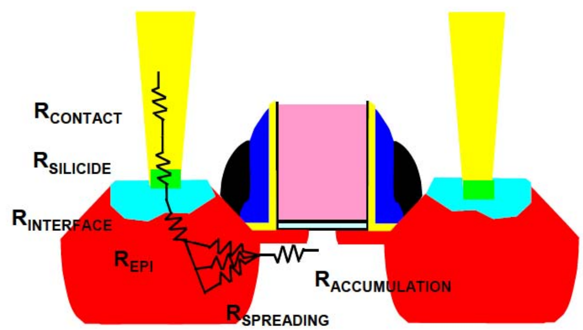

Figure 1: Resistances in a planar device[1]

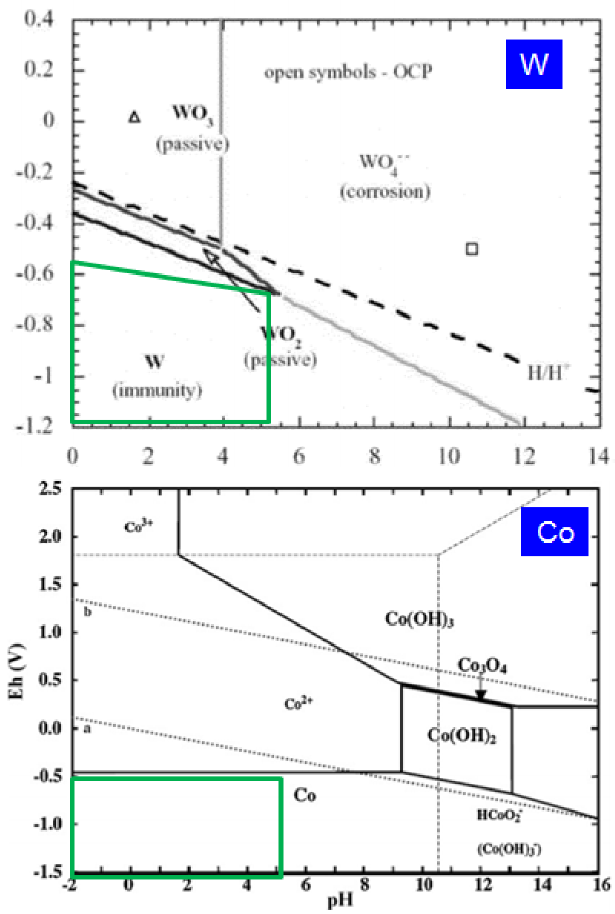

Figure 2: Pourbaix diagrams of W-H_2O and Co-H_2O at 25 ^oC. Green boxes show approximate area where both W and Co are passivated.