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Wet Cleaning and Surface Preparation for SiGe and Ge

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Advances in the downscaling of semiconductor devices and the continued reduction of the physical gate oxide thickness have forced silicon to its ultimate physical limits. Alternative group IV and III/V materials as SiGe, Ge, GaAs, InGaAs and InP, have been considered as new materials for the later 10-nm generations due to their advantages regarding the electron and hole mobilities. However when introducing those new channel materials in the FEOL process they bring new challenges with respect to surface preparation. Their challenges and potential solutions must be understood to guarantee successful implementation.

This study focuses on the development of new chemistries and techniques for Ge surface cleaning in terms of PRE (Particle Removal Efficiency) and MRE (Metal Removal Efficiency) in order to identify the optimal process conditions. As shown in Figure 1, reported at ECS meeting in 2011[1], particulate contaminations can be removed by the lift-off phenomena using ozonated water but, (>3nm) minimum amount of Ge loss is required to obtain sufficient PRE. New studies show that by applying diluted APM for high pH oxidative chemistry, Ge loss can be minimized (<1nm) while having effective particle removal (>90%). However since evaluated dAPM (200:1:20,000) still etches Ge layer, it might impact the concentration controllability and reproducibility. As shown in Figure 2, metals can be effectively removed from Ge surface with a HF/HCl solution.

Therefore, we suggest a two-step cleaning process: O3/NH4OH mixture for PRE and HF/HCl mixture for MRE.

[1] H. Takahashi, et al., *ECS Transactions*, 2011 41 (5) 163-170

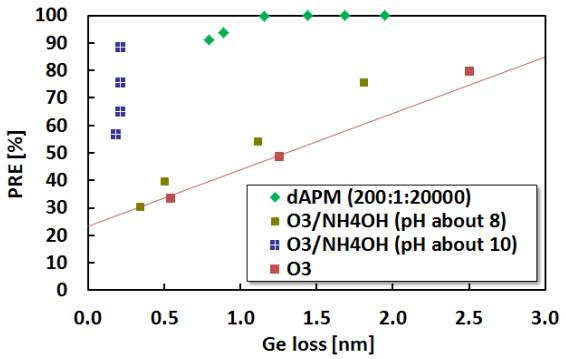

Figure 1. Removal efficiency of a 30-nm SiO2 slurry particles on a Ge as a function of Ge loss with dAPM and O3/NH4OH mixture

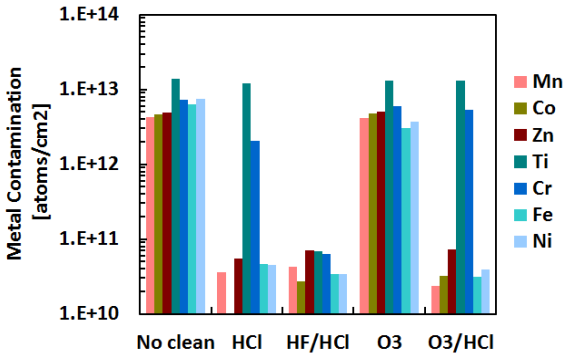

Figure 2. Residual metal contamination detected by TXRF on Ge surfaces after different kind of wet treatments on controlled contaminated Ge surfaces