Low Temperature Borophosphosilicate Glass (BPSG) Process for High Aspect Ratio Gap Fill

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Abstract

As a premetal dielectric, borophosphosilicate glass (BPSG) has been widely used for device planarization. Device evolution towards smaller feature size and restrictions on BPSG reflow temperature budget make a void-free BPSG gapfill a challenging task. This work investigates the extendibility of the current BPSG process using ozone/tetraethoxysilane chemistry [1].

The results of reduced temperature (<750^{0}C) BPSG reflow gap fill of high aspect ratio (AR>6) structures using sub-atmospheric chemical vapor deposition (SACVD) are discussed. High ozone concentrations (>10%) and subsequent reduction in deposition rate significantly improved gap fill capability (Fig.1). Steam anneal ambient was used, which also improved BPSG gap fill. The well-established BPSG reflow trend was reproduced within the investigated ozone concentration process window. It was found that a decrease in dopant concentration enhances the as-deposited film conformality but reduces the reflow capability.

Secondary Ion Mass Spectrometry (SIMS) was utilized to measure dopant concentration depth profiles. Optimized high ozone process (ozone concentration 10-20%) showed smooth interface dopant distribution as well as improvement in film thickness uniformity compared to low ozone process (ozone concentration 5-10%). Limits on boron doping as well as the influence of ozone concentration and process parameters on gap fill and yield were investigated (Fig.2). Further process improvement was achieved by an increase in BPSG deposition temperature. Optimization of BPSG deposition process allowed to extend the life of BPSG reflow at significantly lower temperature budget.

References

[1] L-Q Xia, et. al. “High Aspect Ratio Trench Filling Using Two-Step Subatmospheric Chemical Vapor Deposited Borophosphosilicate Glass for <0.18mm Device Application”, *J. Electrochem. Soc.*, 146, 5, 1999

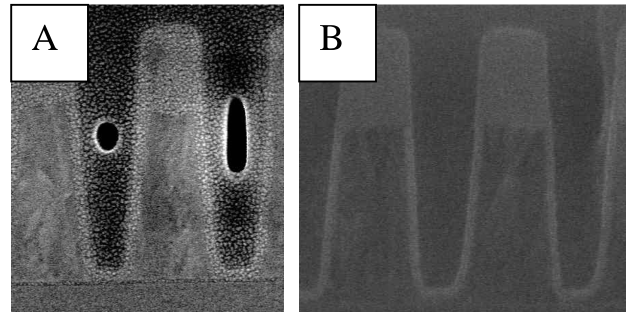

Figure 1. BPSG gap fill of structures (AR-5.5); T=725^{0}C

A – Low ozone process; B – High ozone process

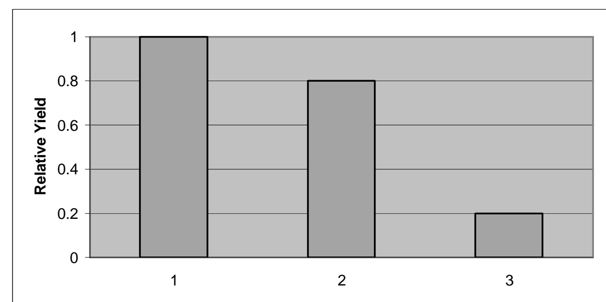

Figure 2. Relative yield of BPSG processes
1 – High ozone; 2 – Low ozone;
3 – High ozone/High Boron (>7 wt.%)

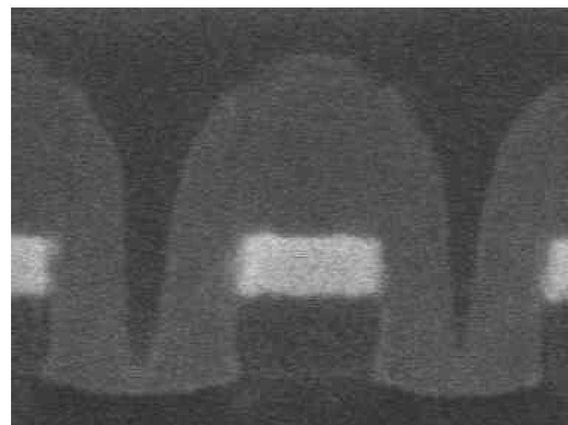

Figure 3. Void-free BPSG gap fill of tapered structures (AR-7). Reflow temperature: T= 700 ^{0}C