Monitoring of yield-critical STI oxide voids and residues in HAR structures

Authors: Uwe Streller, Carlos Mata: Infineon Technologies SC300 GmbH & Co. OHG; Martin Tuckermann: KLA-Tencor

Compared to previous design rule generations, sub 100nm design rule DRAM development and production face unique challenges. As a result, innovative defect inspection and yield control are critical to enable faster development and ramp to production.

Infineon Technologies Dresden is currently running 90nm design rule in production at its 300mm facility. In addition, 70nm design rule products are under development. Process changes, especially in the front-end-of-line, were causing several yield issues, and required a method of more intense monitoring to prevent yield busts.

One issue was caused by residues in high aspect ratio (HAR) structures in the nearly filled trenches after the buried strap etch step. These residues appear either attached around a part of the trench wall or as a bridge-like structure down at the bottom of the trench structure. These residue affected a number of trenches across a large area that, about two days later, could be easily detected as previous layer defects in the subsequent IT etch step. Therefore, the intention with the new inspection step on buried strap etch was to detect the defect at the exact process step in order to have a much faster feedback loop.

STI voids were the second yield issue that required monitoring. Tiny oxide voids occurring between the active areas of the STI module are increasingly more critical with decreasing design rules, as they get filled in subsequent process steps, causing shorts and degrading device reliability.

Due to the size and severity of both defects, both yield issues required increased, highly selective monitoring and process improvement. A proposed solution utilized a darkfield inspection system that combines traditional laser scattering technology with high-resolution imaging to offer critical sensitivity and high throughput (TPT). KLA-Tencor's PUMA 9000 darkfield patterned wafer inspection enabled Infineon to establish an effective HAR residue and STI void monitoring strategy, and systematically work on process improvements.

Understanding of the process issues of the HAR structure residues raised two main concerns relative to the inspection. First, because the residues appeared as clusters (which form a signature), there was uncertainty about the average size of the clusters detected as well as the capture rate of residue defects in isolated trenches. Figure 3 provides evidence that there was a higher capture rate of larger clusters, and that isolated trenches were also captured, albeit at a smaller frequency. Second, the orientation of the laser beam incidence with respect to the symmetrical axis of the trench, as well as a special polarization scheme of the illumination and collecting light, were essential to capture the signature. There was concern that the orientation of the signature itself did not influence the detection.

Selective sensitivity and high-TPT inspection are key to effective STI oxide void capture. In this study, inspection sensitivity was adjusted very specifically towards open voids, with very low nuisance defect detection. All TPT and magnification modes investigated had sufficient sensitivity towards the void defect type to capture all the relevant signatures.

In this work, we demonstrated that an inspection technology that offers selective sensitivity at high TPT can very effectively address two major yield-limiting process issues in advanced DRAM production and, therefore, enable a much faster development and ramp.