

Advanced monitoring of trace metals applied to contamination reduction of silicon device processing

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ABSTRACT

Metallic contamination has long been known to be a key detrimental factor to device yield, causing degradation of various electrical parameters depending on technology, design and device type [1-4]. Thus, device manufacturing control plans systematically include monitoring of metal contamination and , historically, this has been commonly achieved in-line on monitor wafers through a combination of Total Reflectance X-Ray Fluorescence (TXRF) and post anneal Surface Photo Voltage (SPV). In addition, DLTS (Deep Level Transient Spectroscopy) can be extremely powerful for specie identification [5] but is inherently slow not suitable for usage as a process control tool. On the other hand, VPD (Vapor Phase Decomposition) combined with ICP-MS (Inductively Coupled Mass Spectrometry) or TXRF is known to provide both identification and quantification of surface trace metals at lower detection limits that TXRF alone[6, 8]. We have also shown that VPD ICP-MS on thick oxide could be used for control of ion implant induced contamination [7].

Going further in terms of capability improvement, we are moving to a clean room compatible, automated VPD / ICP-MS running in full automation mode from wafer loading to results data upload. Ultimate detection limits can be reached, down to a few 10^6 at/cm² for certain species. In addition, the system is capable, through the use of adequate chemistries to allow monitoring of either surface or bulk contaminants on wafers. In this presentation we will show preliminary data which illustrate the strong capabilities of the system in a R&D and production environment in comparison with TXRF, SPV and manual VPD

Tools	SPV	TXRF	VPD-TXRF	VPD-ICPMS (manual)	VPD-ICPMS (automated)
Method	Minority carrier diffusion length	Surface analysis	Oxide analysis	Oxide decomposition and analysis	Oxide or several layers decomposition and analysis
Destructive	Yes / Feed activation	No	Yes	Yes	Yes
Spot size analysis	1 mm	1 cm	Full wafer	Full wafer	Average value of area
Depth analysis	10-750 μm	1 μm	1 μm to 0.2 μm	1 μm to 0.2 μm	Native oxide to 20 μm
Element	All metals generating deep traps	Over Na	Over Na	Over Li	Over Li
Sensitivity	$5 \cdot 10^7$ at/cm ²	Fe: $3 \cdot 10^8$ at/cm ² Al: $5 \cdot 10^8$ at/cm ²	Fe: $1 \cdot 10^6$ at/cm ² Al: $5 \cdot 10^6$ at/cm ²	Fe: $1 \cdot 10^6$ at/cm ² Al: $2 \cdot 10^6$ at/cm ²	Surface: Fe: $7 \cdot 10^6$ at/cm ² Al: $8 \cdot 10^6$ at/cm ² Bulk: Fe: $8 \cdot 10^{13}$ at/cm ³ Al: $2 \cdot 10^{14}$ at/cm ³

Fig 1 : Figures of merit of automated VPD ICP-MS in comparison with other techniques

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