Ultrathin SOI Wafers Fabrication and Metrology

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SOI material is now established as the substrate of choice for advanced microprocessors applications, pushing SOI technology to ultrathin layers and high volume production. When reviewing ITRS roadmap targets [2], several challenging items appear. Silicon film thickness and uniformity are the most aggressive, with values typically of 10nm and ± 5%, 6σ. These requirements, leads to 10Å thickness accuracy on a 300mm wafer. Smart Cut[1] SOI solution to this manufacturing challenge will be discussed. Gaps need to be closed also regarding metrology requirements, with a special focus on thickness monitoring and defectivity control. In addition, surface nanotopology properties have to be assessed with needs for new metrology solutions.

In order to scale existing Unibond® strategy to ultra thin new 300mm Unibond® products have been developped. Uniformity results are shown for a 200 Å silicon layer, exhibiting a ± 20Å uniformity, all wafers all sites, using a 3mm edge exclusion (Fig.1). Then, outstanding performance are achieved both in terms of wafer-to-wafer and on-wafer uniformities, demonstrating no showstopper for Smart-Cut® technology when talking about ultra thin film SOI (Fig. 2). As a general trend, it appears that such high uniformity needs to be guaranteed whatever the spatial wavelength of the measurement down to Å scale what is currently the domain of roughness measurement, . The "nano-uniformity" will certainly be the key challenge rising metrology difficulty. Surface nanotopology measurement coupled with AFM measurements allows to extend uniformity analysis to mm and µm scale.
While taking benefits from 200 mm volume production maturity, all other SOI structure properties such as defectivity, surface and interface quality, metallic and organic contamination levels are proving the same high level of quality than 200mm Unibond®. Process optimization are now involved in order to further improve uniformity for film thickness down to 100 Å.

In production thickness monitoring, each wafer is measured using more than 1700 points in 200mm and 4000 points in 300mm. Then, plotting min-max values for each wafer (M-3σ and M+3σ), overall uniformity is obtained, all wafers, all sites (Fig. 1). Uniformity is then driven by 2 parameters, wafer to wafer mean thickness variation and on-wafer sigma. Actual repeatability performances of commercially available ellipsometers and reflectometers on ultrathin SOI structures are not compatible with ± 10Å specifications. Then, inspection strategy is discussed in terms of measurement techniques and patterns.

Using laser scattering inspection systems for defect detection on silicon wafers , the major limitation for low threshold operation is surface roughness, which increases the background noise measured from the wafer[3]. This background scattering signal generated by the micro-roughness is often called haze. It has been demonstrated in the case of SOI wafers that reflectivity is an additional contributor to wafer noise. Such reflectivity changes (Fig. 3) could lead to threshold limitations during inspection from 100nm to 200nm for SOI wafers showing surface properties equivalent to bulk silicon [3]. Reflectivity also impacts sizing accuracy on the wafer inducing correlation between size and thickness uniformity.

Smart Cut® process has been successfully involved for 12" wafers SOI production. Unibond ultrathin SOI is following ITRS roadmap and 12" volume production is now ramping up. While scaling down film thickness, layer uniformity, nano-uniformity and defectivity are the most important challenges for manufacturing and metrology.

[1] M. Bruel, Nuclear Instruments and Methods in Physics Research B, Vol. 108, P.313, 1996.
[2] ITRS 2001 Roadmap, http://public.itrs.net
[3] C.Maleville et al., 2000 IEEE SOI conference proceeding, p.107.

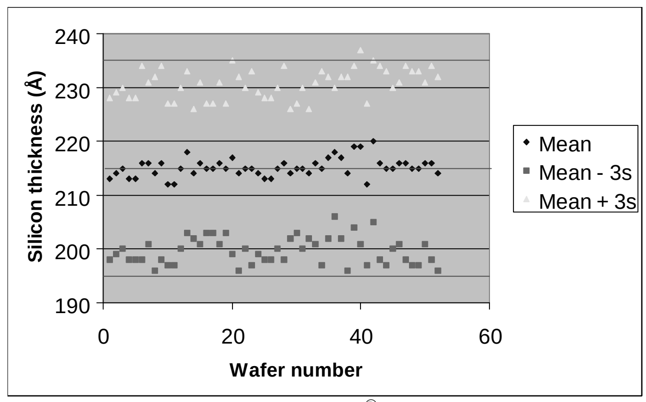

Figure 1: 300mm Unibond® silicon thickness .215/1450Å wafers verifying ±20Å, all wafers, all sites.

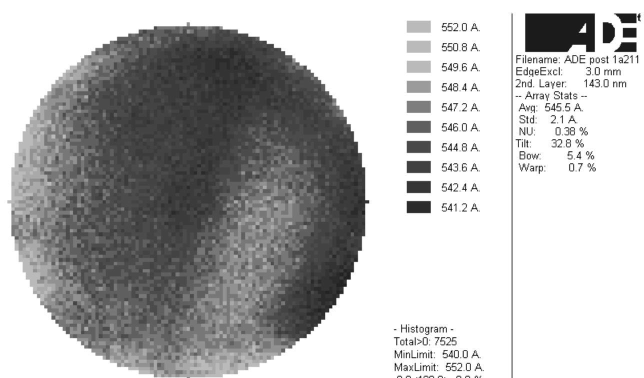

Figure 2: Thickness map of a 550/1500Å Unibond® wafer showing a 2.1Å uniformity (1σ), 3mm EE.

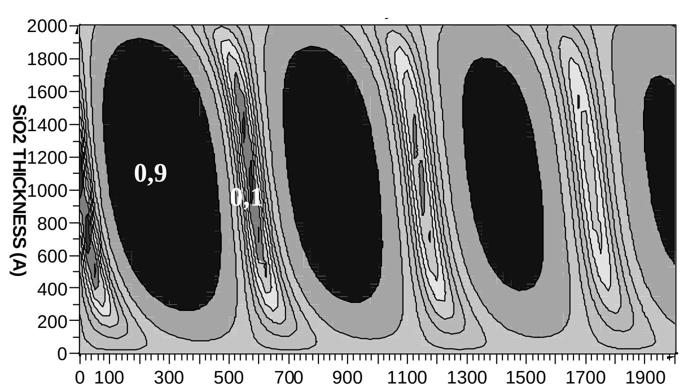

Figure 3: 2D reflectivity curves showing oxide and silicon thicknesses influence on reflectivity (s polarization, oblique incidence, λ=488nm).