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Applications Note

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Advanta Polished Wafer: Cost-effective Advanced Product Available Today

Description

Advanta wafers have low COPs and high GOI performance. During crystal growth, conditions are carefully controlled so that only a small number of agglomerated vacancy defects occur in the center region of the wafer. The annular region outside of the central vacancy core is free of any agglomerated defects. Advanta wafers can also be enhanced using MEMC's Magic Denuded Zone® (MDZ®) thermal treatment. This produces robust internal gettering protection early in the IC fabrication process with deep precipitate-free zones and oxygen precipitate densities in the ideal range for effective gettering.

Benefits and Features:

Reduced COPs decreases possibility of yield degradation due to crystal-related defects (e.g. junction leakage)

Low cost of manufacturing leads to cost effective solution as compared to other advanced wafer types

Enhancement by MDZ® creates deep precipitate-free zone maintained throughout customer processing, improving device yield and reliability potential

Built-in IG through MDZ® eliminates the need for customer oxygen outdiffusion and nucleation cycle and leads to improved customer cost of ownership

Robust IG protection through MDZ® is insurance against device yield upsets caused by metallic contamination

Technical Details

The low defect density requirements of the sub-0.25μm device generations have driven the development of several wafer alternatives. The main challenge of controlling defects in polished wafers has been to suppress the growth of both agglomerated interstitial defects and agglomerated vacancy defects during the crystal growth process. Agglomerated vacancy-related defects are known commonly as D-defects or as Crystal Originated Pits (COPs) when they intersect the wafer surface. Although recent data has shown a decreasing sensitivity of Gate Oxide Integrity (GOI) to COPs at gate oxide thicknesses of less than 100Å[1,2], it is likely that the presence of the vacancy-related defects will have some impact on device performance and yield.

Advanta is a product where the crystal growth process is controlled to ensure a low agglomerated vacancy concentration confined to a central core region. Other options for achieving very low COP densities include annealed wafers where near-surface COPs are eliminated by long, high temperature annealing processes or by covering the COPs with a thin epi-layer, similar to MEMC's Epi-II product. Another approach is the complete suppression of the formation of agglomerated defects (vacancy and interstitial) during crystal growth, such as HPS-II.

GOI vs. Density of Vacancy-Related Defects

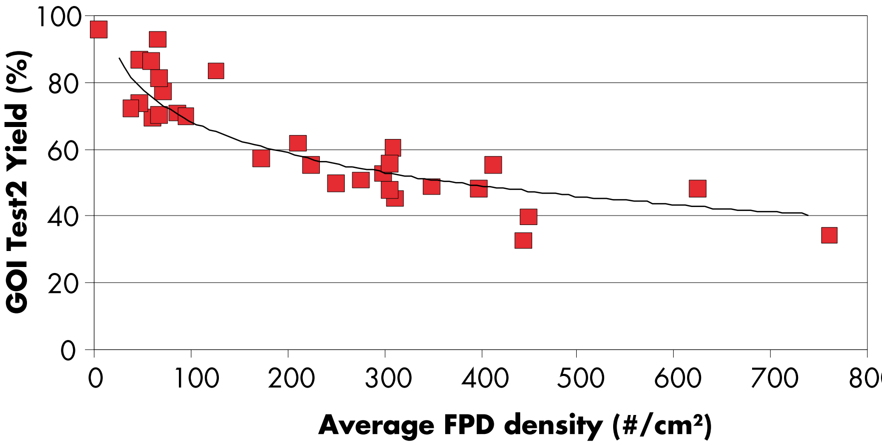

Figure 1: *Reduction of COP/FPD density produces material with high GOI.*

Formation of Vacancy Defects during Crystal Growth

The benefits of Advanta wafers arise because the crystal growth process is designed to ensure that the agglomerated vacancy defects are confined to a central core region and that their concentration remains low. The outer annular region surrounding the vacancy core is free of any vacancy or interstitial agglomerated defects. To understand how these benefits arise, it is necessary to understand how vacancies and interstitial defects are incorporated into a growing crystal.

It is now generally accepted that the theory of Voronkov[3] holds true in that the concentration of vacancies (V) or interstitials (I) incorporated at the growing solid/liquid interface during crystal growth depends on the ratio of V/Gs. In this ratio, V is the pull rate of the crystal and G_s is the axial temperature gradient at the melt/solid interface. For values of V/G_s greater than a critical value, C_{crit}, the dominant point defects incorporated will be vacancies while for $V/G_s < C_{crit}$, the dominant point defect type will be interstitials. Detailed characterization work at MEMC on crystals grown using various combinations of high and low pull rate profiles has determined that the critical value, $C_{crit} = 2.1 \times 10^{-5}\ cm^2\ s^{-1}\ K^{-1}$. This value is in good agreement with the original work of Voronkov and with other published data[4].

Results

The careful control of the crystal growth process ensures that the agglomerated defects are confined to a central core region and the outer annular region remains defect free. The reduction of the overall wafer COP/FPD (flow pattern defects) density produces material with a high GOI yield as can be seen from Figure 1.

Intrinsic Gettering

In addition to low COP densities, many customers also require intrinsic gettering. This is achieved in Advanta wafers by using MEMC's proprietary process Magic Denuded Zone® (MDZ®). The process produces an ideal density of oxygen precipitates and a deep precipitate-free zone following a thermal cycle without the need to introduce additional, costly out-diffusion, nucleation and growth thermal cycles.

Summary

Advanta wafers are Czochralski-grown silicon wafers, which have low COP densities and high GOI performance. The benefits of Advanta wafers are:

- Low Crystal-Originated Particles (COPs) and defect densities
- High GOI
- Cost effectiveness compared to other advanced wafer types
- Very Low OISF
- Zero Large Dislocation Loops
- Excellent Intrinsic Gettering (using MDZ®)

REFERENCES:

[1] F. González, M.R. Seacrist, M.J. Binns, A. Wang, S. Pirooz and R. Barbour. In "Analytical and Diagnostic Techniques for Semiconductor Materials, Devices and Processes". The Electrochemical Society, Pennington.NJ. PV- 99-16, p. 496, 1999.

[2] T.R. Bearda, J. Vanhellemont, P.W. Mertens and M. Heynes in "High Purity SiliconV", The Electrochemical Society, Pennington. N.J. PV 98-13, p258, 1998.

[3] V. V.Voronkov. J. Cryst Growth, 59, 625, 1982.

[4] W. von Ammon, E. Dornberg, H. Oelkrug and H. Weidner. J. Cryst. Growth, 151, 273, 1995.

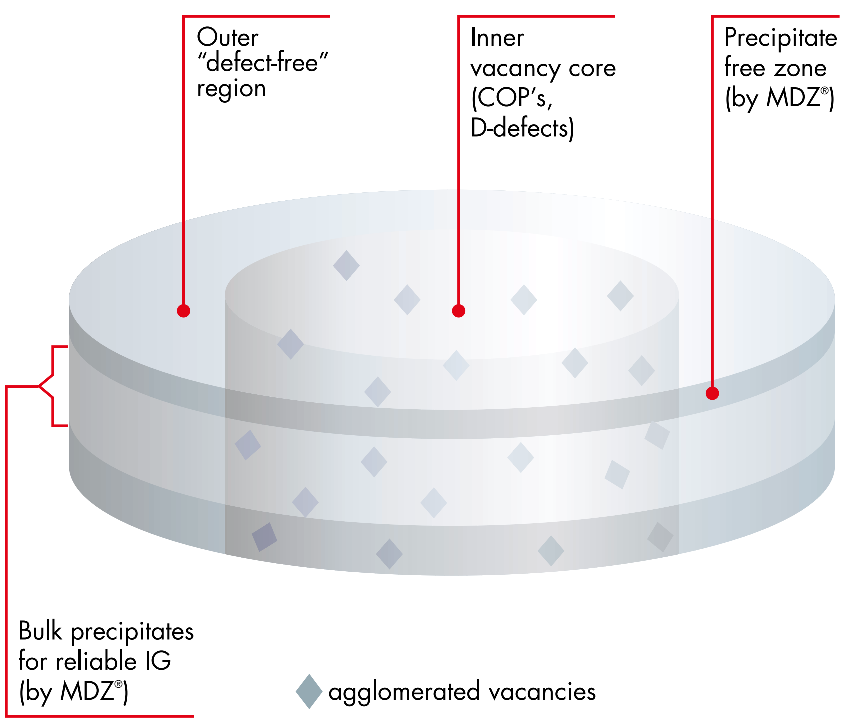

Figure 2: *Schematic of an Advanta wafer (not to scale).*