MEMC®

TECHNOLOGY IS BUILT ON US®

Robust Internal Gettering Providing Cost Savings And Process Simplification

MDZ

MAGIC DENUDED ZONE

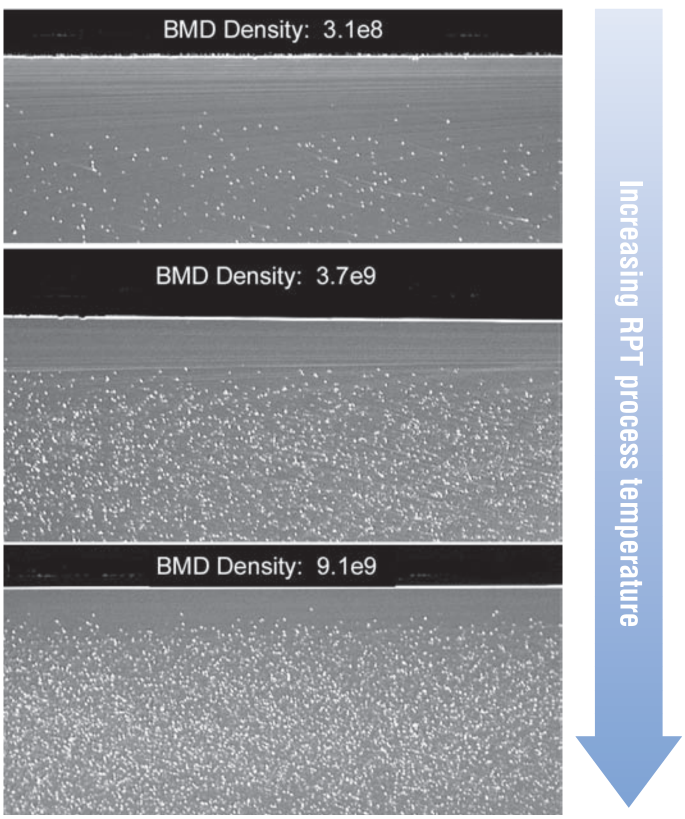
BY MEMC

Improve Device Performance, Reliability, and Cost Of Ownership

- Precisely controlled precipitation of oxygen significantly decreases risks that may lower device yields
- Elimination of long thermal treatments in the IC Fab process results in lower cost and process simplification
- Robust and reliable internal gettering
- Oxygen precipitation density and depth distribution are pre-programmed to ideal targets
- Superior to other gettering processes and products such as Hydrogen annealing and Nitrogen doping

The MDZ® wafer

Magic Denuded Zone® (MDZ)® is a patented, rapid method of achieving reproducible and reliable internal gettering in silicon wafers. It is a Rapid Thermal Process (RTP) based technique in which the oxygen precipitation behavior is controlled by the manipulation of vacancy rather than oxygen concentration profiles. MEMC has engineered the RTP process to create a vacancy concentration depth profile that effectively pre-programs the precipitate-free zone depth and precipitate density of the wafer to ideal targets. MDZ® produces a silicon wafer with ideal oxygen precipitation behavior, and reproducible and reliable IG which is nearly independent of the initial oxygen concentration, the thermal history effects from crystal growth, and the IC fab process application.

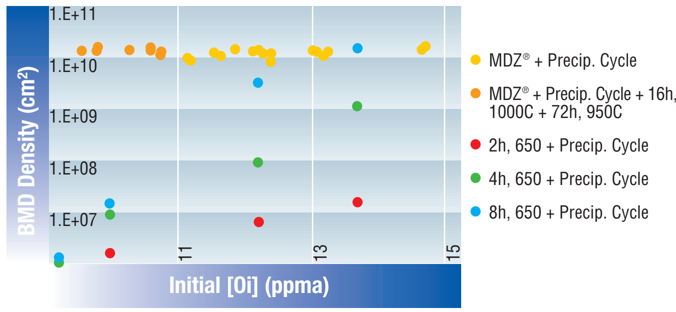


Precipitation Control with MDZ®: Cleaved cross-section with decorated oxygen precipitates. BMD density can be precisely targeted with the RTP process temperature while maintining a deep precipitate-free zone.

Benefits

Controlling oxygen precipitation during the processing of integrated circuits has proven to be one of the most difficult challenges in silicon wafer defect engineering. Uncontrolled precipitation of oxygen in the near surface region of the wafer represents a risk to device yield. In MDZ®, MEMC provides a product with internal gettering that is nearly independent of initial oxygen concentration,

BMD Density vs. [Oi]:
MDZ® Compared To Conventional Denuding And Renucleation

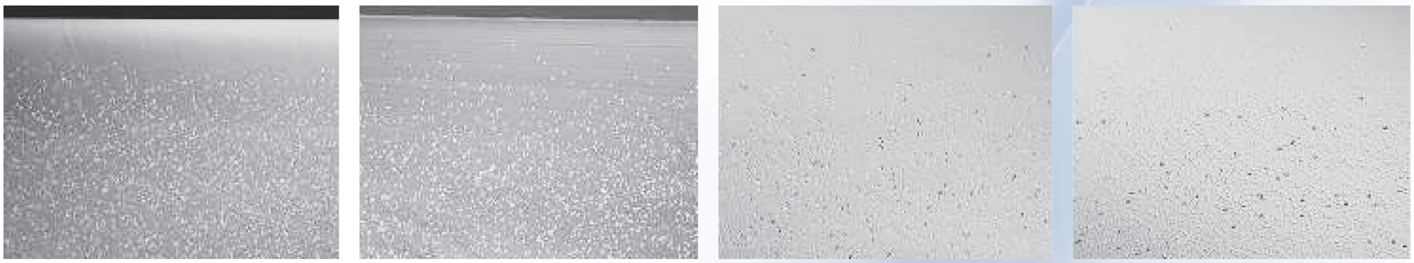


MDZ®: Independence of Precipitate Density from Initial Oxygen. Precipitate density is strongly dependent on oxygen concentration for non-MDZ® wafers and shows essentially no dependence on oxygen for MDZ® wafers.

wafer position and thermal history effects from crystal growth, and the IC process application. MDZ® also offers the advantage of eliminating time-consuming IC fab annealing, while also meeting the needs of increasingly lower thermal budget IC processes. MDZ® offers significant advantages over the conventional approach in terms of simplicity, reliability, and process design. Since MDZ® wafers do not rely on long thermal treatments in the IC fab process, IC fabs can potentially reduce their costs and simplify their processes, resulting in better yields and higher efficiency.

Technical Details

Oxygen diffusion rates are very slow compared with vacancy diffusion rates. Conventional approaches to precipitate-free zone formation require hours of oxygen out-diffusion furnace time at temperatures greater than 1000°C during IC processing. This must then be followed by a low temperature (hours at 650°C) oxygen precipitate nucleation furnace cycle in order to achieve



Independence of Application: Despite large differences in the IC thermal process details, the PFZ depths and BMD densities are nearly the same for all four different processes.

a precipitate density for effective IG. The result is still strongly dependent on the initial oxygen concentration and thermal history from crystal growth both of which can vary with position along the length of the crystal. In MDZ®, the precipitate density and depth distribution are determined by the vacancy concentration profile and are decoupled from the oxygen and crystal growth influences, and the details of the IC thermal process. The entire MDZ® process is accomplished in less than one minute.

The formation of MDZ® occurs in two rapid stages:

Stage 1: The vacancy concentration profile is created in three phases during the rapid thermal processing:

- The wafer temperature is increased rapidly to the point where vacancy-interstitial pairs are formed efficiently and their concentrations are high.
- While the wafer is briefly held at temperature, the vacancy and interstitial concentration profiles separate to their respective equilibrium concentrations by diffusion to the wafer surfaces. At the MDZ® process temperature the vacancy equilibrium concentration is higher than the interstitial concentration.
- During cooling, the vacancies try to maintain equilibrium by diffusion to the wafer surface, but they do not diffuse fast enough.

Stage 2: Oxygen clustering to the vacancy template occurs rapidly during the first IC thermal process. Vacancies greatly enhance the rate at which oxygen clusters by providing free volume that reduces the energy necessary for the oxygen clusters to form. The vacancy profile is consumed by the clustering process and nucleation of oxygen precipitates stops. The density of oxygen precipitates is determined by the vacancy concentration programmed into the bulk of the wafer and not the concentration of oxygen. The precipitate density is targeted to the 5E9cm-3 range considered to be ideal for IG. The depth distribution of the oxygen precipitates is programmed by the vacancy depth profile. The vacancy concentration in the first 50µm of depth is below the critical concentration for enhanced oxygen clustering resulting in a precipitate-free zone of at least 50µm and typically 80µm.

Summary

MEMC's Magic Denuded Zone provides robust and reliable oxygen precipitate depth distributions, deep precipitate-free zone, and consistent bulk precipitate densities. These results are nearly independent of initial oxygen concentration, wafer position and thermal history effects from crystal growth, and the IC process application. MDZ® offers significant advantages over the conventional approach in terms of simplicity, reliability, and process design. The MDZ® process does not rely on long thermal treatments in the IC fab process, potentially enabling IC fabs to reduce their costs and simplify their processes, resulting in better yields and higher efficiency.

References:

R. Falster, D. Gambaro, M. Olmo, M. Cornara, and H. Korb, MRS Spring 1998 Meeting, San Francisco.

R. Falster, SEMI 1998 Silicon Wafer Symposium.

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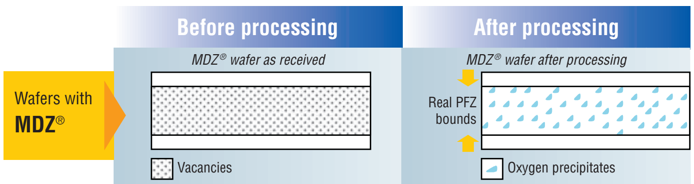
The MDZ® Advantage

The MDZ® process produces an ideal density of oxygen precipitates and a deep precipitate-free zone. This eliminates the need for additional, costly out-diffusion, nucleation and growth thermal cycles in the customers' manufacturing lines.

The MDZ® Advantage



MDZ® installs in the wafer the right precipitate depth distribution, at the wafer level.

Features	Benefits
Results are nearly independent of: • initial Oxygen concentration • wafer thermal history • details of crystal pulling process • IC application	• Reduction of long thermal treatments in the IC process • Elimination of specific tests for new processes • IC process simplification • Wafer specs simplification • Lower processing cost • New degree of freedom to move silicon inventory
Ideally tuned precipitation in all wafers for: • density • PFZ depth	• Robust and repeatable gettering • Reduces risks that may lower device yields • Eliminates all sources of the unpredictability of oxygen precipitation
Available for • 150mm • 200mm • 300mm	• Adaptable to present and future technologies

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MEMC Electronic Materials, Inc.
501 Pearl Drive (City of O'Fallon)
P.O. Box 8
St. Peters, Missouri 63376

(636) 474-5000
www.memc.com

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