Brewer Science® ProTEK® PSB

Photosensitive Alkaline-Resistant Coating

Where innovation takes flight!℠

F.6.6.7009.A
Effective Date: 01/26/2009

ProTEK® PSB Coating

ProTEK® PSB, a photosensitive alkaline etch mask, allows bulk silicon micromachining late in the process while preserving the metal stack

- Apply over CMOS structures due to low process temperatures
- Reduce processing time compared to SiN etch masks
- Provide higher throughput than single-wafer DRIE by using batch processing

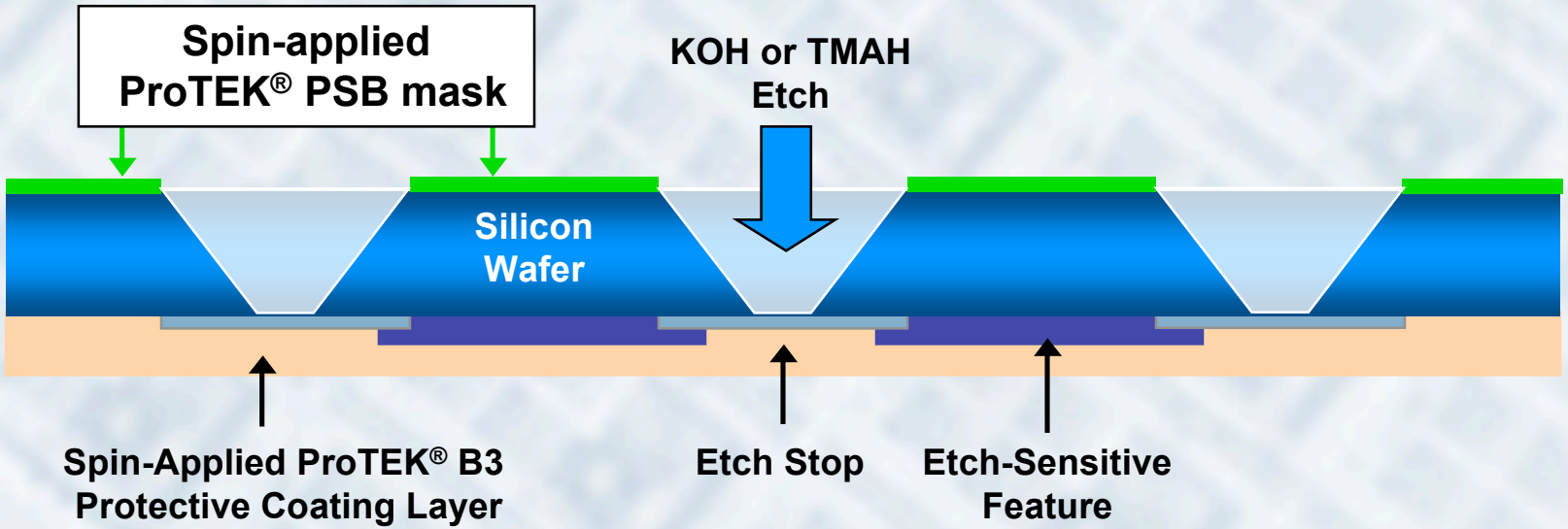
ProTEK® PSB Coating Outline

- ProTEK® PSB coating use
- Low-temperature process - allows use with previously formed CMOS structures
- Eliminates process steps in comparison to CVD SiN
- Improved throughput - *wet versus dry etch rates*
- Process results
- Film properties
- Summary

ProTEK® PSB Coating Use

Applied over CMOS or MEMS structures

- Prior to creating through-silicon vias (TSVs)
- Prior to creating SiN membranes
- Utilizes low-cost alkaline bulk micromachining



Brewer Science® ProTEK® PSB Photosensitive Alkaline-Resistant Coating

ProTEK® PSB Low-Temperature Process

Allows application over organics and metals

ProTEK® PSB coating deposition temperature is lower than:

- PECVD nitride deposition (≧ 250ºC)
- LPCVD nitride deposition (≧ 500ºC)

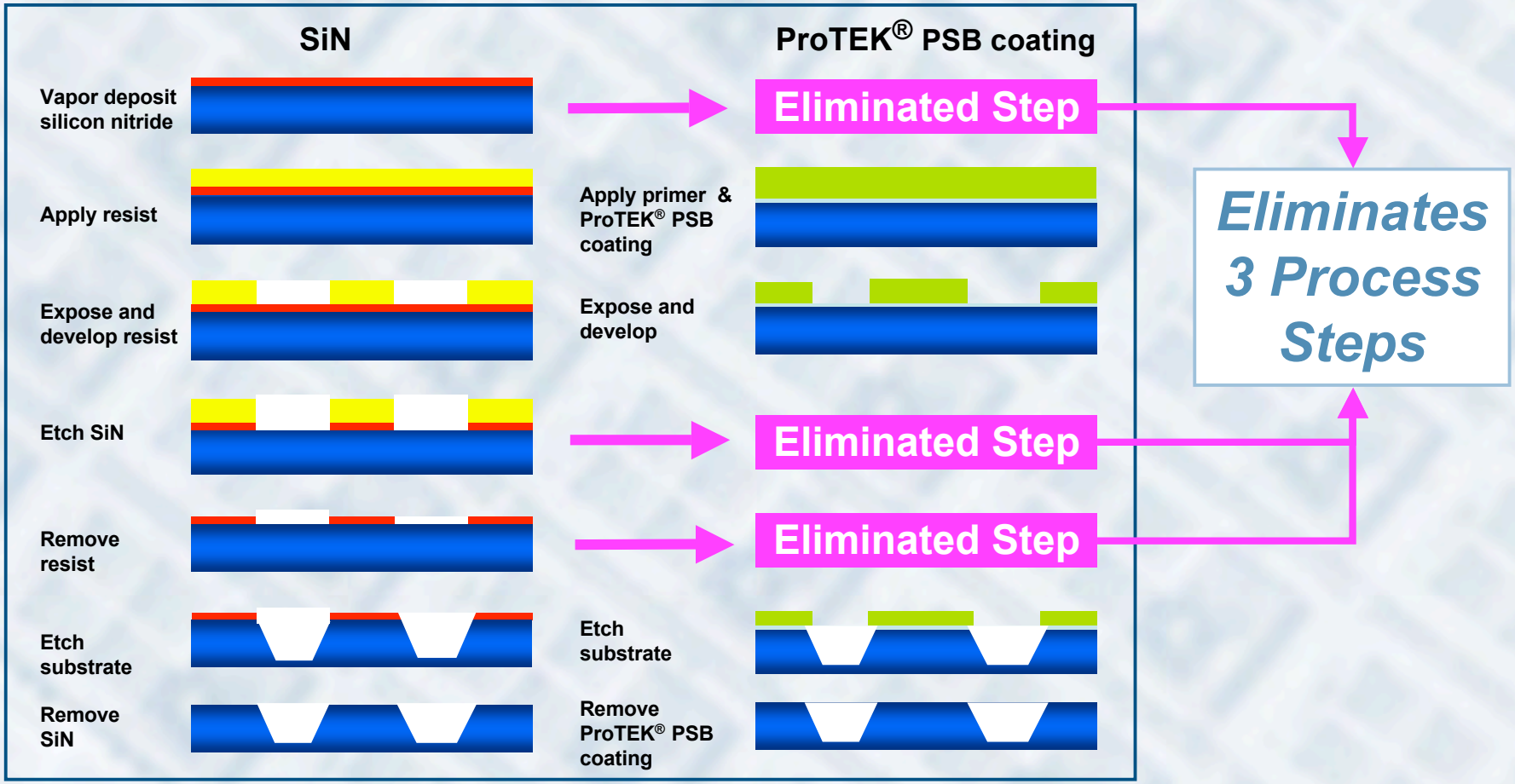
Process Details:

ProTEK® PS Primer bake
- 110ºC for 60 s
- 220ºC for 300 s

ProTEK® PSB coating bake
- 110ºC for 120 s PAB
- 110ºC for 240 s PEB
- 220ºC for 180 s Final Cure

ProTEK® PSB process temperatures never exceed 220ºC

ProTEK® PSB vs. CVD SiN Process



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ProTEK® PSB Higher Throughput

Throughput nearly 2x faster than dry etching

TMAH wet etch rate: 7.5 wafers/hour
Bosch dry etch rate: 4.3 wafers/hour

Process Details:

TMAH Wet Etching
50-wafer batch process
TMAH:H_20 = 22:78, at 90ºC
Total etch time = 6.66 hours
Throughput
= 50 wafers/6.66 hours
= 7.5 wafers/hour

TMAH Etch Rate for <100> Silicon
= 0.9 µm in 22% TMAH and 78% water at 90ºC
*R. Hull [*Properties of Crystalline Silicon *(INSPEC, London, 1999)]*

Bosch Dry Etching
Single-wafer process

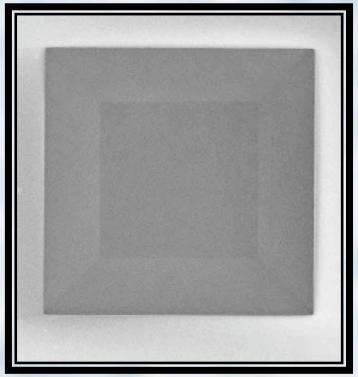
Total etch time = 0.23 hours
Throughput
= 1 wafer/0.23 hours
= 4.3 wafers/hour

DRIE Etch Rate for <100> Silicon
*= 14 µm for a 35-µm diameter and 360-µm depth via SEMI and Yole Developpement [*Global MEMS/ Microsystems Market and Opportunities *(July 2007)]*

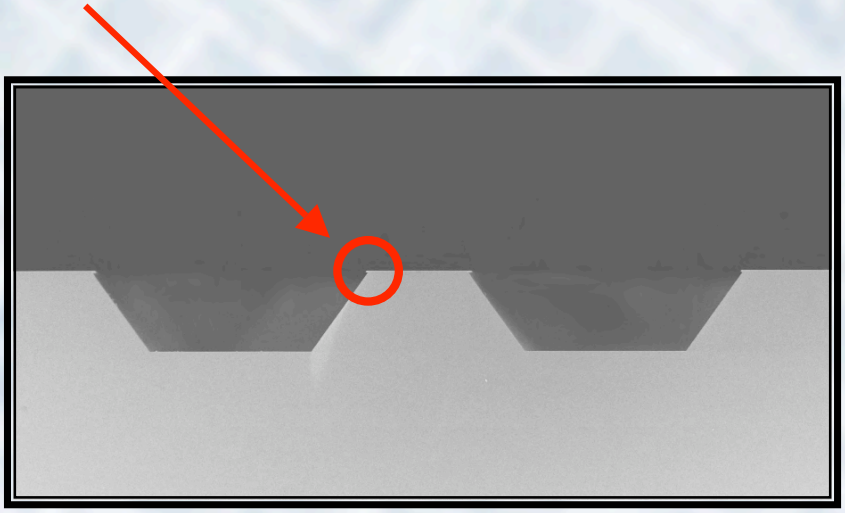
ProTEK® PSB TMAH Wet-Etch Process Results

As an etch mask, ProTEK® PSB performs as well as SiN

1.2% undercut was obtained after etching in
25% TMAH at 90°C for 3 hours



Top-down view of 250-µm vias



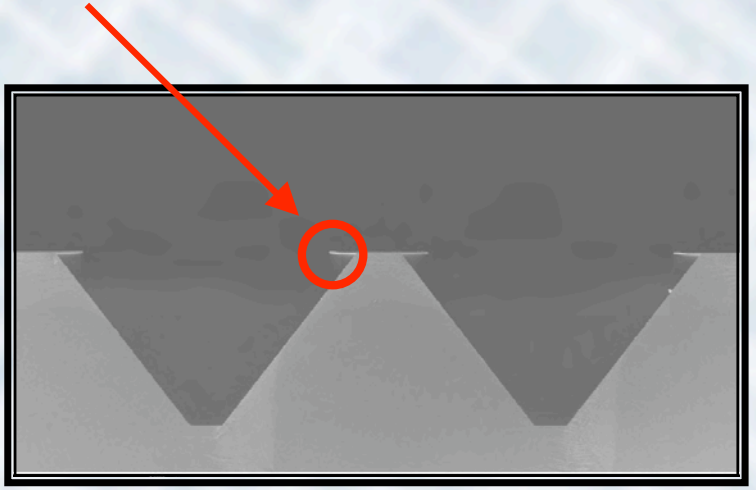
Cross-sectional view of 250-µm trenches

ProTEK® PSB KOH Wet-Etch Process Results

Consistent undercut achieved in KOH

14.9% undercut was obtained after etching in 30% KOH at 75°C for 4 hours.

Top-down view of 250-µm vias



Cross-sectional view of 250-µm trenches

Key Properties of ProTEK® PSB Coating

- High resistance to most alkaline etchants
  [KOH, TMAH, NaOH]
- Consistent mask performance
  [Minimal TMAH undercut, 15% undercut with KOH]
- Mild acid resistance
  [BOE (6:1), HCL (15%)]
- Spin-applied coating to various thicknesses
  (1.5 µm to 5 µm)
- Photosensitive
  (broadband and i-line)
- Solvent developable
- Withstands process temperatures up to 250ºC

Summary

ProTEK® PSB coating provides:

- Ability to apply over organics and metals
- Fewer processing steps than CVD
- Higher throughput than single-wafer DRIE

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ProTEK® PSB Supplemental Outline

ProTEK® PSB Coating Application Process

1. Wafer pretreatment
2. Applying ProTEK® PS Primer
3. Applying ProTEK® PSB Coating
4. Developing ProTEK PSB Coating
5. Alkaline etch
6. ProTEK® PSB Coating Undercut
7. Maximum Process Delay Information
8. Removal
9. Rework
10. Devices that can use ProTEK PSB Coatings

Wafer Pre-treatment

Before primer application:

- Rinse with NH_4OH:H_2O_2:DI water (1:1:40) for 180 seconds at room temperature
- Rinse with HCL:H_2O_2:DI water (1:1:40) for 180 seconds at room temperature
- Spin dry

Pre-treatment reduces undercut and improves consistency.

Applying ProTEK® PS Primer Coating

- Spin apply primer at 1000 rpm for 60 seconds
- Soft bake at 110ºC for 60 seconds
- Hard bake at 220ºC for 300 seconds

Hard bake of the primer has a major impact on undercut.

Applying ProTEK® PSB Coating

- Spin apply ProTEK PSB coating at 1500 rpm for 60 seconds
- Soft bake at 110ºC for 2 minutes
- Expose with 500 mJ of i-line or broadband
- Post-exposure bake at 110ºC for 2 minutes
- Spin develop for 90 seconds (see next slide)
- Hard bake at 220ºC for 3 minutes

Developing ProTEK PSB Coating

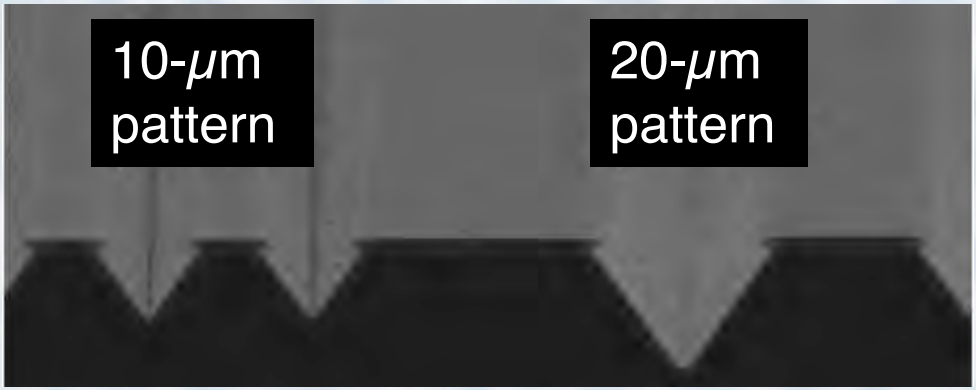
Spin Develop

- Dispense EL: 300 rpm, accelerate at 1000 r/s^2 for 10 seconds
- Spin dry: 2000 rpm, accelerate at 10,000 r/s^2 for 5 seconds
- Dispense EL: 300 rpm, accelerate at 1000 r/s^2 for 5 seconds
- Spin dry: 2000 rpm, accelerate at 10,000 r/s^2 for 5 seconds
- Dispense DI water: 300 rpm, accelerate at 1000 r/s^2 for 8 seconds (IPA can be used in place of DI water)
- Spin dry: 2000 rpm, accelerate at 1000 r/s^2 for 40 seconds

Alkaline Etching (e.g., KOH)

Etch in 30% KOH at 75ºC for the recommended time, rinse with DI water, and dry.

ProTEK® PSB Coating Undercut

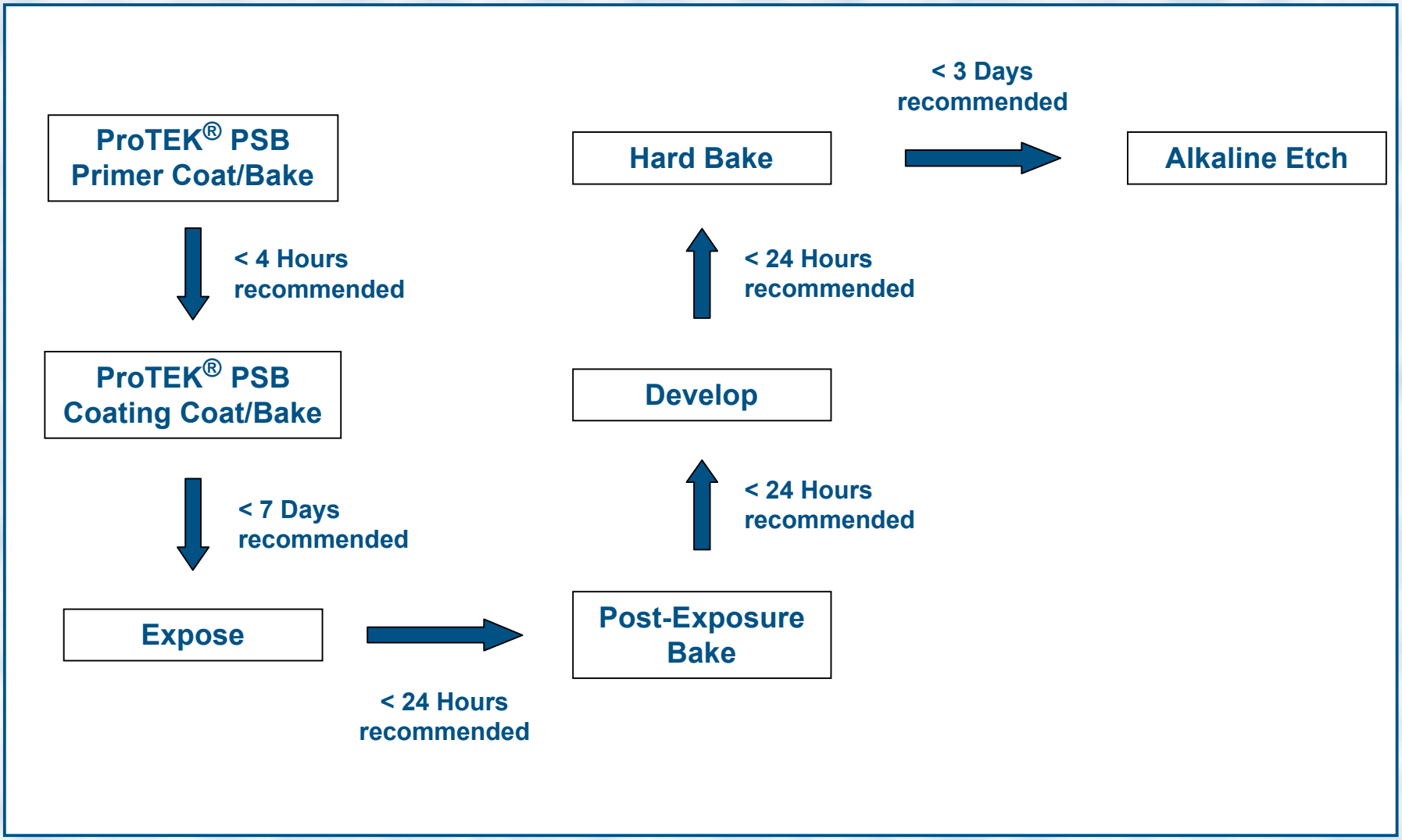


ProTEK® PSB coating mask undercut is determined by:

- Alkaline etchant used (KOH has larger undercut than TMAH)
- Bath concentration (undercut decreases with higher concentrations)
- Bath temperature (undercut increases with higher temperature)
- Wafer surface characteristics (decreases with RCA-1 and RCA-2 cleaning)

The undercut is consistent for stable etching conditions and stops when <111> planes intersect.

Maximum Process Delay Information



Removal of ProTEK® PSB Coating

Wet Process

- Heat Nano-Strip™ to 100ºC
- Immerse wafers coated with ProTEK® PSB coating for 30 minutes
- Rinse in DI water
- Dry

Dry Process

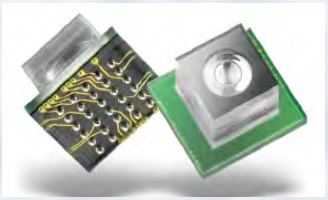
- Etch bulk film with O_2 plasma (75sccm O_2, 400W,75mTorr)
- Final etch with O_2:CF_4 (2:1), (56sccm O_2, 19sccm CF4, 400W, 100mTorr)

Rework of ProTEK® PSB Coating

- Remove ProTEK® PSB coating by dry etching or with Cyantek Corporation Nano-Strip™ product
- RCA-1 Clean
- RCA-2 Clean

Devices that can use ProTEK PSB Coatings

Low-cost TSV deep etching and wafer protection during sensitive after-handling steps



Advanced Packaging
3-D TSV & Wafer-Level Packaging

Membrane Micromachining

MEMS
Pressure Sensors, Si-Microphones, Inertials Sensors, MOEMS, ioMEMS & Microfluidics

Structure Micromachining & Wafer Protection

Compound Semiconductors
Near-Field RF, OLED

Nozzle Creation

MEMS Fluid Handling
(Ink-jet, BioMEMS & Microfluidics,…)

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