



SEMI® INTERNATIONAL STANDARDS

Benefit for wafer manufacturers and their customers when aligning EP metrology by applying SEMI M73

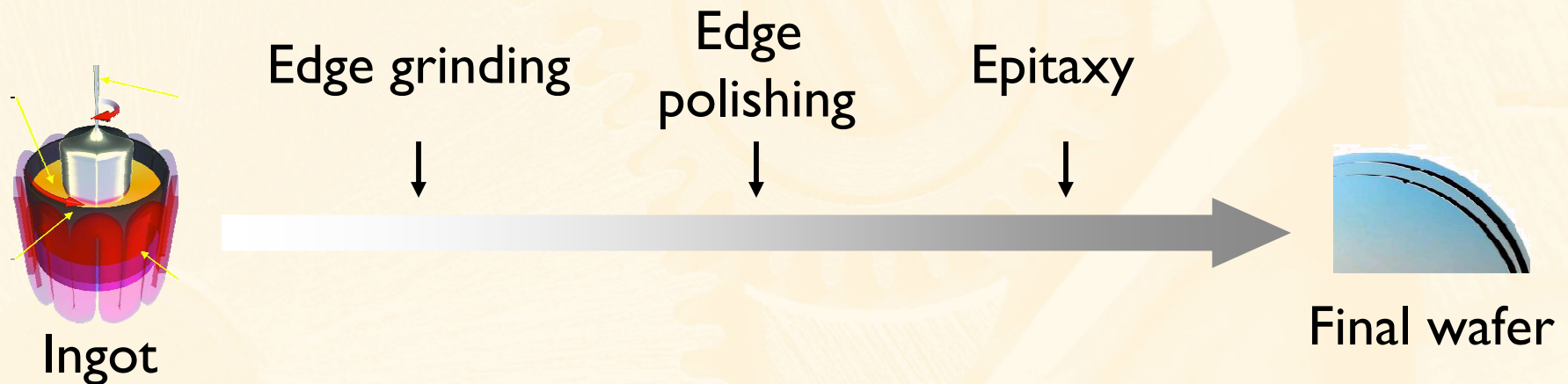
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Siltronic AG

Outline

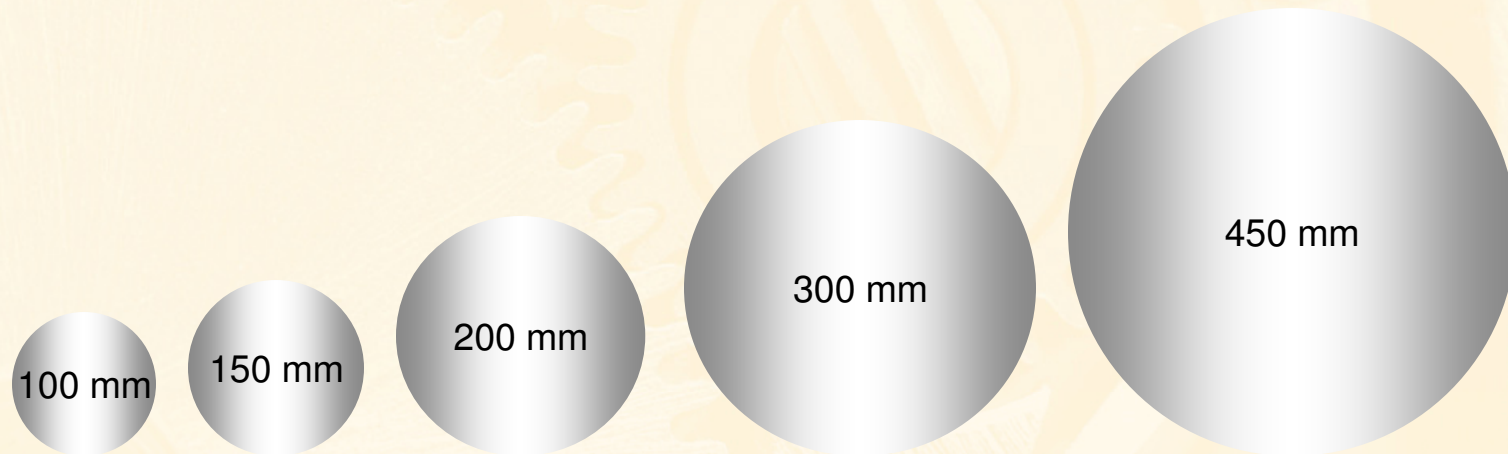
- Edge profile measurement in wafer production
- SEMI M73 comparison to established metrics
- Benefits of SEMI M73

Wafer Manufacturing Process



- Edge profile (EP) defined by edge grinding process
- Subsequent process steps affect profile: edge polishing, epitaxy
- Control of edge profile necessary

Different Products

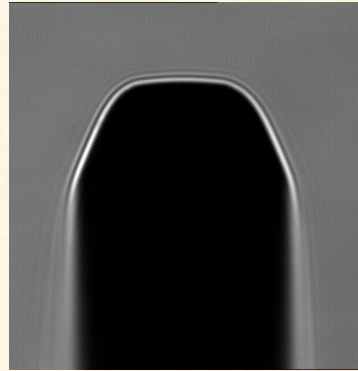


- Large wafer diameter and thickness range
- Until recently, SEMI MI only defined a wafer profile template
- Edge profile details were agreed upon with individual customer
- No standardized EP metric established

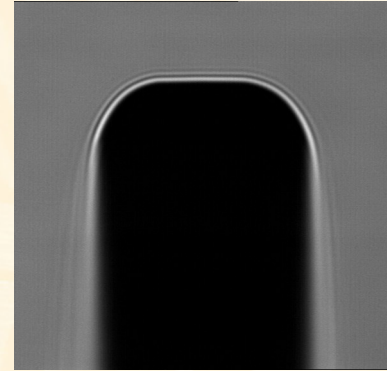
Different Edge Profiles



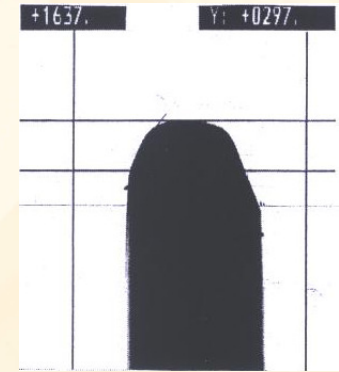
round
(Type C)



blunt
(Type A)



blunter
(Type B)



asymmetric

- Edge profiles vary strongly for different products
- Edge profile metrology hardware is wafer size specific
- Historically, hardware suppliers use proprietary edge profile metrics

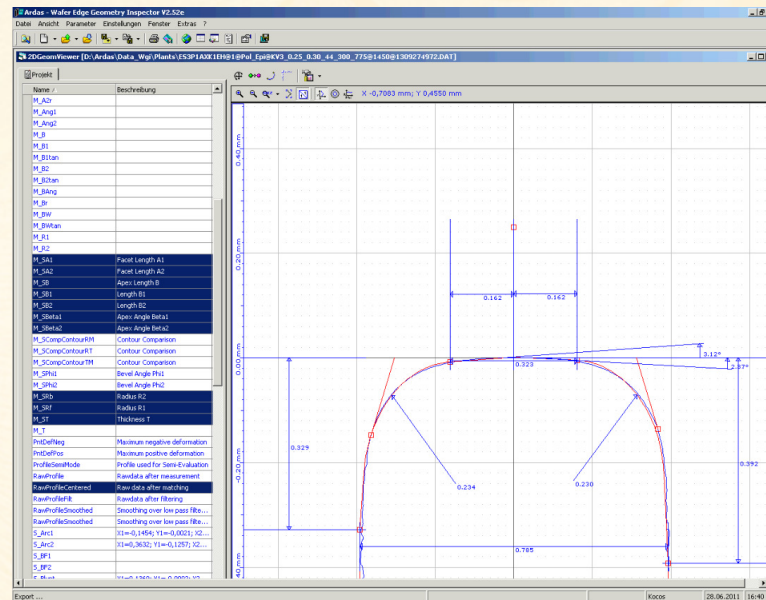
Different Edge Profilers

- Different hardware applying several measurement technologies
- No unique method to evaluate acquired edge profiles (best fit approach, window based fit, template)
- Measurement results from different tools are not comparable
- No common terminology among wafer manufacturers and customers

- SEMI M73 has been established to unify edge profile measurement (2009)

Implementation of M73 by KoCoS

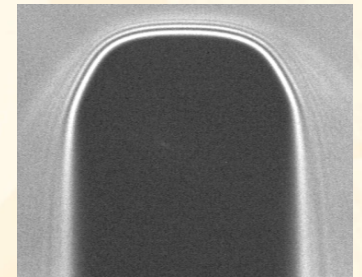
- SEMI M73 metrics available for KoCoS tools



- KoCoS implementation has been used for following investigations

Comparison of Different EP Metrics: Correlations

- 10 polished wafers with blunt edge
- Measured with SEMI M73 and proprietary metrics



Parameter	R ² M73 vs Metric I	R ² M73 vs Metric II	R ² Metric I vs Metric II
Front edge width	0.32	0.12	0.43
Front bevel angle	0.74	0.26	0.18
Front shoulder radius	0.47	0.73	0.74
Apex length	0.92	0.94	0.88
Back shoulder radius	0.78	0.86	0.83
Back bevel angle	0.48	0.42	0.01
Back edge width	0.77	0.56	0.10
Thickness	0.08	0.04	0.05



- Reasonable correlation for apex length and shoulder radii only

Comparison of Different EP Metrics: Matching

- Average values for 10 wafers and differences between metrics

Parameter	M73	Metric I	Metric II	M73-Metric I	M73-Metric II	Metric I-Metric II
Front edge width (mm)	0.267	0.302	0.259	-0.035	0.007	0.042
Front bevel angle (°)	25.6	16.3	22.2	9.4	3.5	-5.9
Front shoulder radius (mm)	0.256	0.253	0.257	0.003	-0.001	-0.004
Apex length (mm)	0.238	0.228	0.337	0.011	-0.098	-0.109
Back shoulder radius (mm)	0.246	0.237	0.235	0.009	0.011	0.002
Back bevel angle (°)	24.5	17.1	23.2	7.4	1.3	-6.0
Back edge width (mm)	0.270	0.297	0.259	-0.027	0.011	0.038
Thickness (mm)	0.776	0.776	0.775	0.000	0.001	0.001



- Considerable bias for non-correlating parameters
- Correlation impossible (profile type and recipe dependent)
- Data not compatible

SEMI M73: Measurement Capability

Best fit metric vs M73-I

Parameter	P/T - Metric I Blunter Profile Type B	P/T - M73 I Blunter Profile Type B	P/T - Metric I Round Profile Type C	P/T - M73 I Round Profile Type C
Front edge width	1.10%	1.43%	2.00%	0.36%
Front bevel angle	NA*	6.57%	4.90%	1.18%
Front shoulder radius	0.90%	0.98%	0.30%	1.00%
Apex length	2.90%	1.43%	NA	0.36%
Back shoulder radius	1.70%	0.84%	0.30%	2.10%
Back bevel angle	NA*	6.15%	4.90%	1.70%
Back edge width	0.70%	2.92%	2.20%	1.14%
Thickness (mm)	5.40%	2.98%	3.60%	1.28%

* Best fit directly connects shoulder to front/back surface

- Significant improvement in bevel angle measurement
- M73-I enables angle measurement for short edge width profiles (Type B)

SEMI M73: Measurement Capability

Method M73-I vs Method M73-II

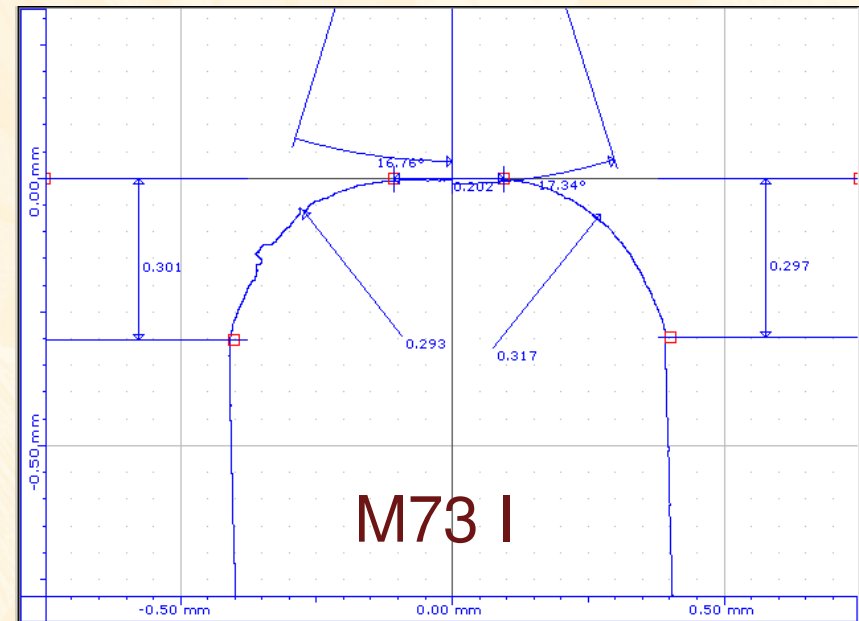
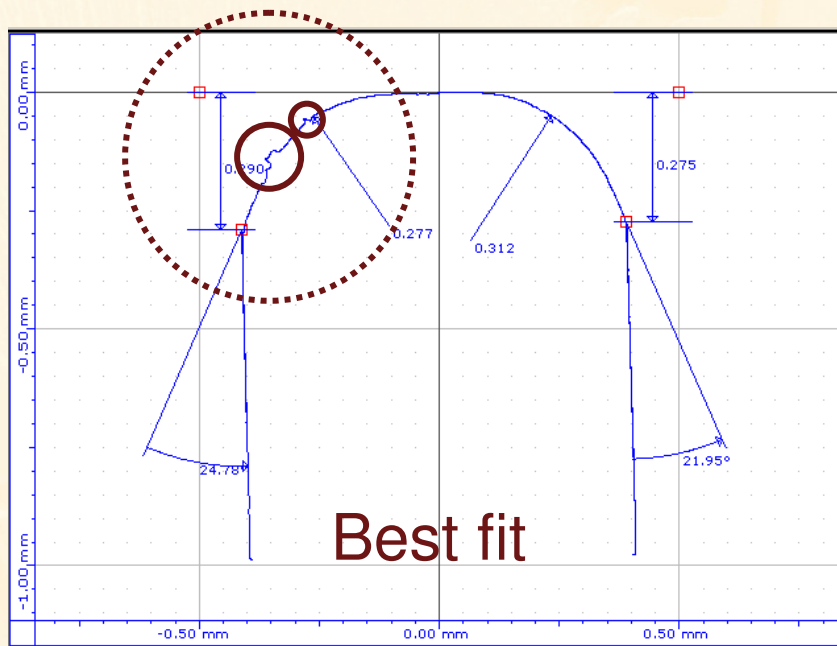
- End of line wafers with Blunter and Round profiles

Parameter	P/T - M73 I Blunter Profile Type B	P/T - M73 II Blunter Profile Type B	P/T - M73 I Round Profile Type C	P/T - M73 II Round Profile Type C
Front edge width	1.43%	2.92%	0.36%	0.28%
Front bevel angle	6.57%	6.48%	1.18%	1.40%
Front shoulder radius	0.98%	1.98%	1.00%	1.41%
Apex length	1.43%	2.92%	0.36%	0.28%
Back shoulder radius	0.84%	3.53%	2.10%	0.91%
Back bevel angle	6.15%	6.20%	1.70%	1.94%
Back edge width	2.92%	3.47%	1.14%	0.04%
Thickness (mm)	3.51%	10.02%	0.52%	1.11%
Mean P/T	2.98%	4.69%	1.05%	0.92%

- M73-I superior to M73-II regarding precision
- More details in presentation from KoCoS

SEMI M73: Impact of Particles

Comparison with Best Fit Metric



- Best fit: Particle affects overall profile (radius, angle, ...)
- M73: Only segment parameter is affected (radius)
- Well suited for non-clean environments

SEMI M73: Recipe Management

- Manufacturing process steps change edge profile (e. g., thickness)
- In general, for each process step a modified recipe and parameter set is necessary, resulting in a large variety of recipes / templates
- M73 recipes defined via edge width only (A_f/A_b)
- Easy transfer of edge profile metrology to 450 mm

SEMI M73

Customer Benefits

- SEMI M73 is an open, well documented metric
- Permits generation of traceable standard samples
- Capabilities for different profile types known
- Comparable supplier data
- Consistent specification format
- Consistent reporting format according to standard
- Hardware platform independent (CofC vs. IQC)

- High quality wafers

Summary

- Importance of edge profile metrology for wafer manufacturing has been shown
- SEMI M73 shows clear benefits over established metrics
- Silicon wafer suppliers as well as customers will benefit from standardized metrology