CMP Conditioner and Pad Characterization

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Conditioner Characterization
Active Diamonds

Active diamonds, or working grit, are defined as those diamonds that modify a pad surface by cutting furrows.

Interferometry of an MMC Mosaic disc with a Teflon coating

PacRim 2005
Active Diamonds

Active diamonds, or working grit, are defined as those diamonds that modify a pad surface by cutting furrows.

All diamonds that cut should wear

but

wear by itself is not proof of cutting.

Interferometry of an MMC Mosaic disc with a Teflon coating

Probably Inactive

Probably Active

PacRim 2005
Furrows are hard to see on commercial pads
... but easy to see on polycarbonate
Conditioner Active Diamond Characterization

MMC TRD 100 grit
8.0 lbf
109 active

US and Foreign Patents

MRS 2007
Active Diamond Locations on the Conditioner
Active Diamonds on IC-1000

IC-1000 pad, no grooves
Mounted on polycarbonate

80 nm Cr layer
Deposited at 70 C

MMC TRD 100 grit
8.0 lbf
145 active
PC undercount: 24%
73 Common
Active Diamond Count vs. Load and Grit Size
Disc is viewed as if transparent from the top.

Reference on left side of plate.
Characterization of Aggressive Diamonds
Matched 2D Image BEFORE Wear
Matched 2D Image AFTER Wear
Preliminary 24 – hr Wear Results

Non-aggressive Diamond

Before

After
Preliminary 24 – hr Wear Results

Aggressive Diamonds Nos. 3 and 4

Before

After

Before

After
CMP Pad Characterization
Laser Confocal Microscopy

Zeiss LSM 510 Meta NLO
How a Laser Confocal Microscope Works

Reflected light near the focal plane reaches the detector; out of focus light does not.
Topography with Confocal Microscopy

**Pad Sample**
IC-1000

**Imaging Conditions**
20x objective
488 nm laser
450 gain
27 pinhole
512 x 512 resolution
450 x 450 μm image
Interferometry vs Confocal Microscopy

White Light Interferometry
~10-50% valid data

Confocal Microscopy
100% valid data
Raw Laser Confocal Topography Images

0.449 x 3.593 mm

IC
Less Aggressive Conditioner

IC
More Aggressive Conditioner

Direction of Pad Rotation
Confocal Contact Area Measurements

- **Near contact interference fringes**
- **Load**
- **Sapphire window**
- **Contact**
- **Far from contact**
- **No reflected image**
- **Black area**
- **Confocal optical slice**

Images show:
- **Far from contact**
- **Contact**
- **Near contact**
Confocal Contact Area Images

IC Pad, Less Aggressive Conditioner
Contact Area Shapes

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10 microns
Contact Area Histogram

IC, Less Aggressive Conditioner
Contact Area Histogram

IC, More Aggressive Conditioner
Contact Area Fraction vs. Pressure

IC, More Aggressive Conditioner
Topography-Contact Area Matching
Topography-Contact Area Matching
Pad Surface Properties

Pad Topography

Contact Area

Materials Model

\[ \frac{\partial \sigma_{ij}}{\partial x_j} = 0 \]

\[ \sigma_{ij} = \lambda \varepsilon_{kk} \delta_{ij} + 2\mu \varepsilon_{ij} \]
Navier-Stokes Solution for Flow over Topography

Velocity magnitude, slurry flow over measured pad topography

Wafer

V = 1 m/s

Measured topography
Navier-Stokes Solution for Flow over Topography

Fluid Pressure

Higher fluid pressure at contacting summit leading edge.

Lower pressure at trailing edge

Localized fluid pressures induced by topography may influence the rate
Example Contact and Fluid Dynamics Analysis

Measured Topography
Example Contact and Fluid Dynamics Analysis

Contacting Summit.

The topography is the same as the previous slide except it is depicted using a color contour map rather than a relief map.
Example Contact and Fluid Dynamics Analysis

Close-up of Region in Contact
Example Contact and Fluid Dynamics Analysis

Fluid Pressure Field (log scale)

Reynolds Equation

5.2x10^5 Pa (75 PSI)
Pad surface properties imply pad displacements from several nm to several hundred nm.