Analyzing Post-CMP Surface Topography from White Light Interference Microscopy

or

What does facial recognition have to do with post-CMP topography maps?

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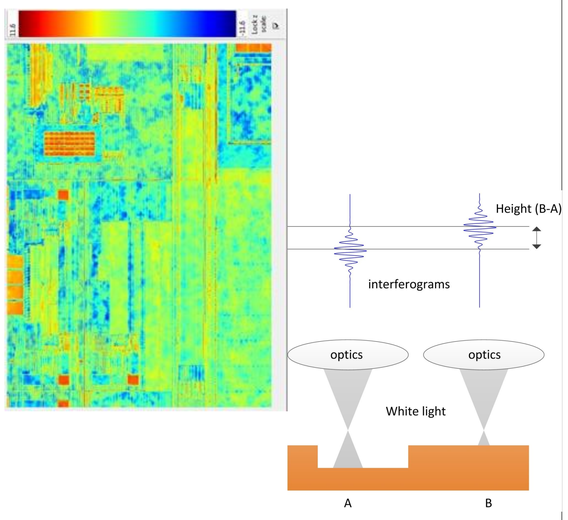
Introduction

The key metric for a successful CMP process is the planarity. Parameters of interest to planarity are tracked for statistical process control (SPC) to keep the process optimized.

The Unifire tool in Fab8 is based on interference microscopy, also called scanning white-light interferometry, and is a technique especially suited for CMP [1-2] because of its ability to measure topography with its large (~mm) area field of view with high spatial (~um per pixel) resolution. The output is an image topography height map. Images can be stitched to produce a full die topography map.

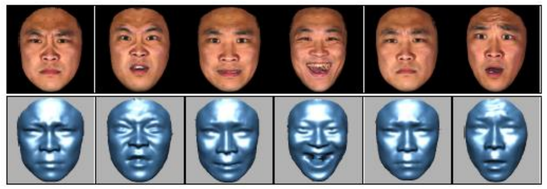


Statistics such as the average height, the height distribution, the kurtosis are output parameters which could be tracked for SPC. In this study the topography maps are analyzed beyond the traditional calculations for height average and distribution.

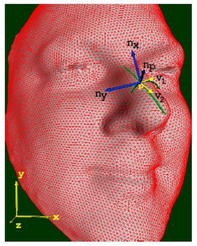
Methods

Surface map analysis [3-4] traditionally used in other fields such as image recognition, facial recognition, and geographical terrain topography are applied to the post-CMP surface topography measurements.

- In Geography, the terrain is classified according to the altitude and slope.
- The motivation is to determine the flow rates of water and sediment and how best to predict drainage.
- In Facial Recognition, the surfaces are classified according to primitive characteristics.



From Ref. [4]



Basic algorithm:

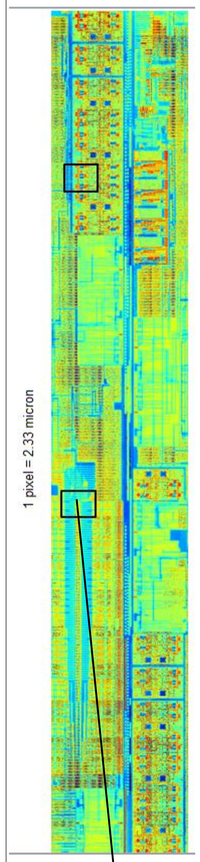
- Divide the topography map into small patches, in this case 7x7 pixels.
- Fit the 7x7 pixels to a surface.
- Calculate characteristics of the surface patch, e.g. gradient, 2nd derivative, amplitude of each.
- Classify each surface patch according to the characteristics.

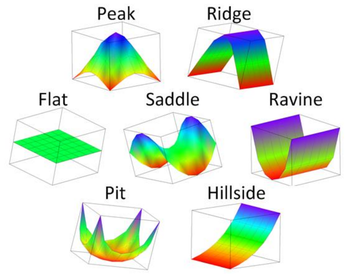
Input\Output	Anger	Disgust	Fear	Happiness	Sadness	Surprise
Anger	80.0%	1.7%	6.3%	0.0%	11.3%	0.8%
Disgust	4.6%	80.4%	4.2%	3.8%	6.7%	0.4%
Fear	0.0%	2.5%	75.0%	12.5%	7.9%	2.1%
Happiness	0.0%	0.8%	3.8%	95.0%	0.4%	0.0%
Sadness	8.3%	2.5%	2.9%	0.0%	80.4%	5.8%
Surprise	1.7%	0.8%	1.2%	0.0%	5.4%	90.8%

From Ref. [4]

Results

Based on the amplitude and direction of the gradient and 2nd derivative, the surface patch is classified into one of seven primitive labels:

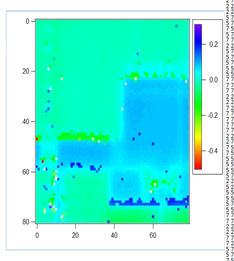


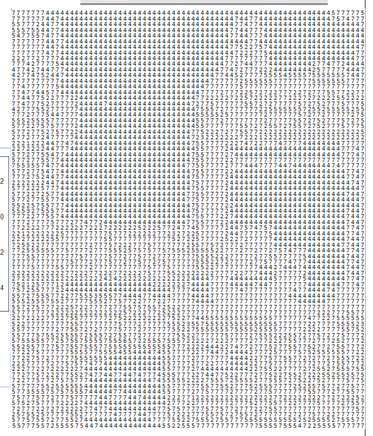


The primitive labels are then applied to each 7x7 patch in the topography image. Statistics are then collected for the number of instances for each label for an image.

In the map below, each label number is the representation of a surface patch.

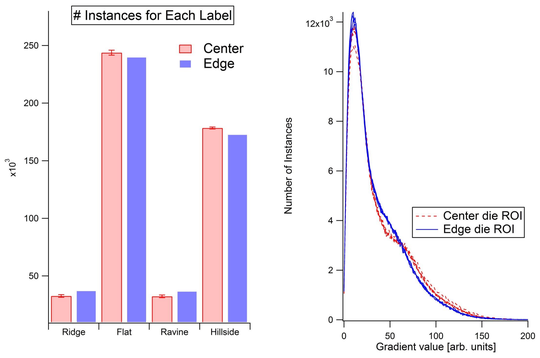
Label	Number Label	Total Instances
Peak	1	6
Ridge	2	1355
Saddle	3	8
Flat	4	2132
Ravine	5	965
Pit	6	1
Hillside	7	935





The label map is similar to the topography image map. With the number of instances for each label, there is now a method to quantify each image. The quantification can be used for SPC.

Conclusion



In addition to the number of instances for each label, analyzing the gradient distribution of the surface patches is another method for quantifying the topography map. Note the difference between center and edge.

In summary, the traditional use of topography maps is to visually inspect images and qualitatively determine flatness, or at the very most, use a simple RMS value. In this work we have developed a method to quantify detailed characteristics of topography maps that is applicable to SPC in a fab environment:

- Distribution of surface patch label instances
- Gradient distribution of the surface patches.

Acknowledgement

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