Development of High Resolution Topographic Characterization at Die Scale by Interferometry

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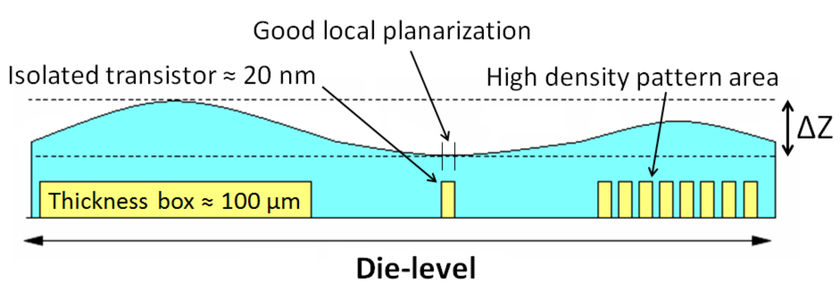
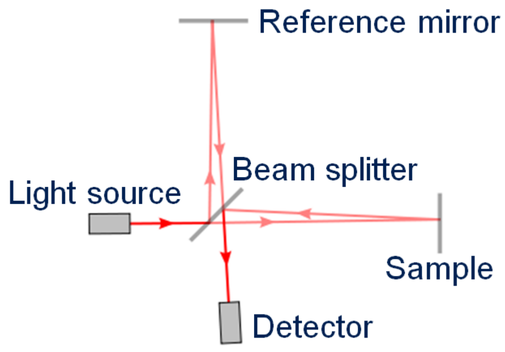
Introduction

Metrology requirements in the semiconductors industry have considerably gained in importance during the last decade. One major metrology issue is to image, at the die-scale, the topography with a nanometric z-resolution and micrometric (x,y) resolution. This need arises from several processes. Due to its specificities Chemical Mechanical Polishing (CMP) is one of them.

CMP specificities :



Experimental and methodology



Interferometry principle (Michelson interferometer)

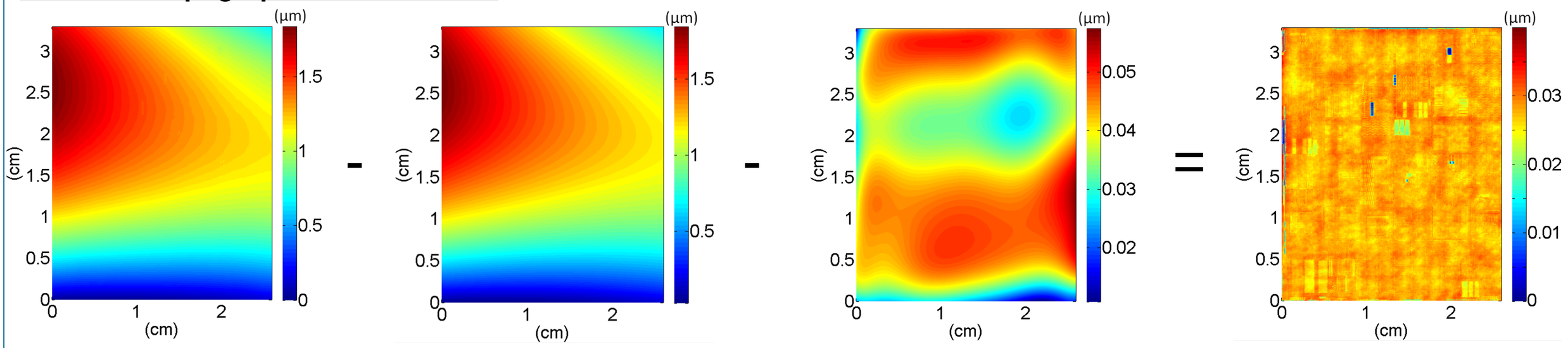
Interferometer type	Michelson
Mode (interferometry)	Phase shifting
Lateral resolution (µm)	3.6
Vertical resolution (nm)	1
Field of view (mm)	2.4x1.8
Stitching	yes

Configuration

A 30 nm tantalum opaque layer is mandatory to suppress the spurious contribution of the transparent overlayers. It is checked by AFM and mechanical profilometer that the underlying topography is not modified by the Ta layer. Moreover die level characterization leads to die level issues, especially for large areas of 9 cm². These problems are:

Results and discussion

Unwanted topographic contributions Characterized by chromatic confocal microscopy, mechanical profilometer and interferometry



Interferometric measurement raw data

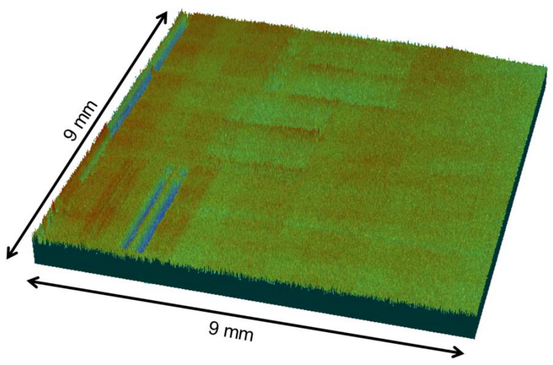
Topographic wafer contributions (bow and warp)

Topographic die contributions (vacuum, chuck and residual wafer contributions)

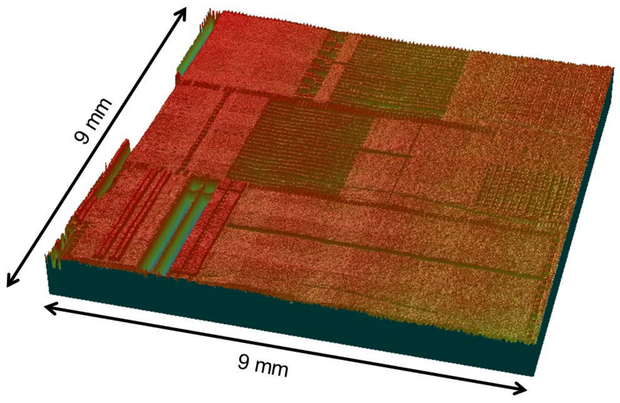
Die measurement without unwanted topographic contributions

At the die scale different contributions make up the low frequency content of the topography

Stitching algorithm



Interferometric measurement with stitching issue



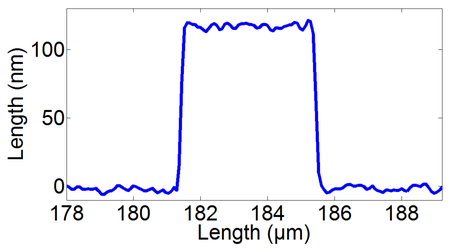
Interferometric measurement without stitching issue

Stitching algorithm reliable for 9 cm² acquisition (300 images)

Filtering

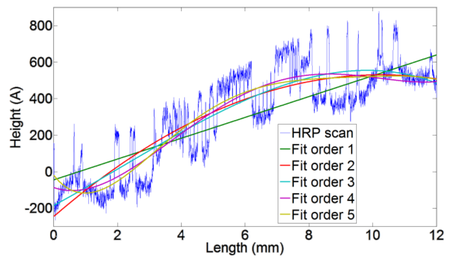
Known filtering methods also had to be evaluated for large and patterned surface topography acquisitions…

Micrometric scale with patterns:



Usual methods (x,y,z) space:
- Polynomial fit on the full scan (order from 1 to 3) ✔
- Polynomial fit on selected areas (order from 1 to 3) ✔

Millimetric / centimetric scale with patterns:



Usual methods (x,y,z) space:
- Polynomial approach even with high order fits the pattern ✘
- Large acquisition make impossible areas selection ✘

All scales with patterns:

Usual method Fourier space:
- Frequency filtering impossible because pattern frequency can be equal to unwanted topographic contribution frequency ✘

Usual filtering methods are not sufficient anymore

To be continued…

Conclusion

This work demonstrates that interferometry is well suited for high resolution (vertical ≈ 1 nm, lateral ≈ microns) topography characterization at the die-scale (several square centimeters). Nowadays, the presence of transparent multilayer hampers optical-based metrology method. However we demonstrate that a Ta cladding layer resolves this problem. We also show that metrology problems induced by the die scale can be solved for area as large as 9 cm². Finally we show that conventional filtering methods are not sufficient anymore in the case of large and patterned surface topography acquisitions. This lack has to be addressed in a future study.