FROM RESEARCH TO INDUSTRY

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IN-DIE HIGH RESOLUTION NANOTOPOGRAPHY DATA, IMPACT IN THE CMP PROCESS MONITORING FOR ADVANCED NODES

N. RUIZ, F.DETTONI, M.RIVOIRE, V.BALAN, C.BEITIA

Contacts :
Carlos.beitia@cea.fr
Patricia-Nathaly.Ruiz@cea.fr

Context

Nowadays , semiconductor industry trends are towards 3D integration and miniaturization. These trends involves dies' manufacturing by stacking several transistors or die layers (figure 1) [1,2] . The interconnections of these layers are essential to assure the system functionality. They quality is guaranteed by the good planarization at die level. This objective can only be obtained by means of chemical-mechanical polishing (figure 2). Different patterns' densities in the die, lead to height variation from some nanometres up to hundreds of nanometres in surfaces length of several millimetres up to centimetres (figure 4). These height variations are known as nanotopography and its measurement will enable polishing efficacy characterization (figure 3).

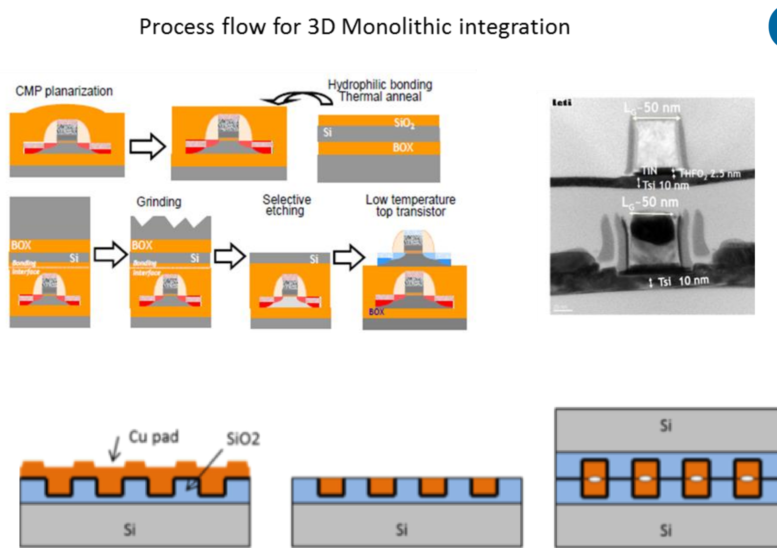


Figure 1: a) 3D monolithic
b) 3D integration Cu-Cu bonding

Chemical mechanical polishing (CMP)

Objective:
layers planarisation

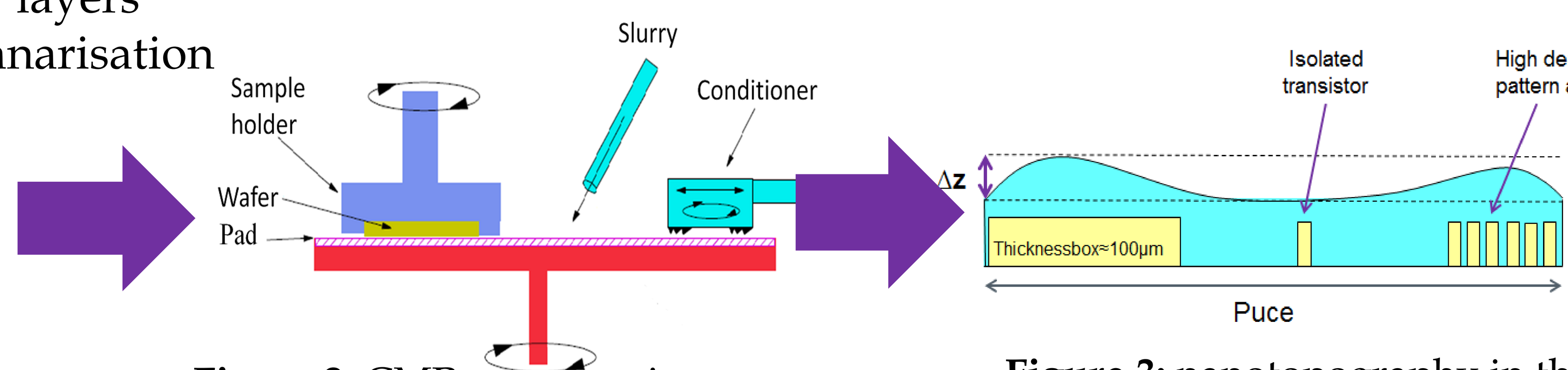


Figure 2: CMP process picture

Figure 3: nanotopography in the die

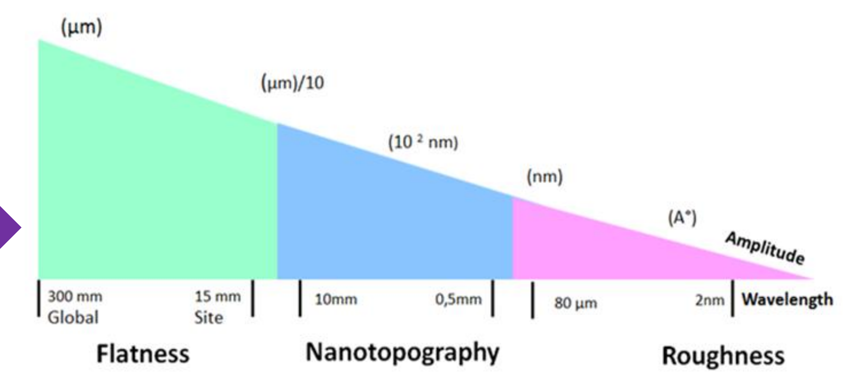
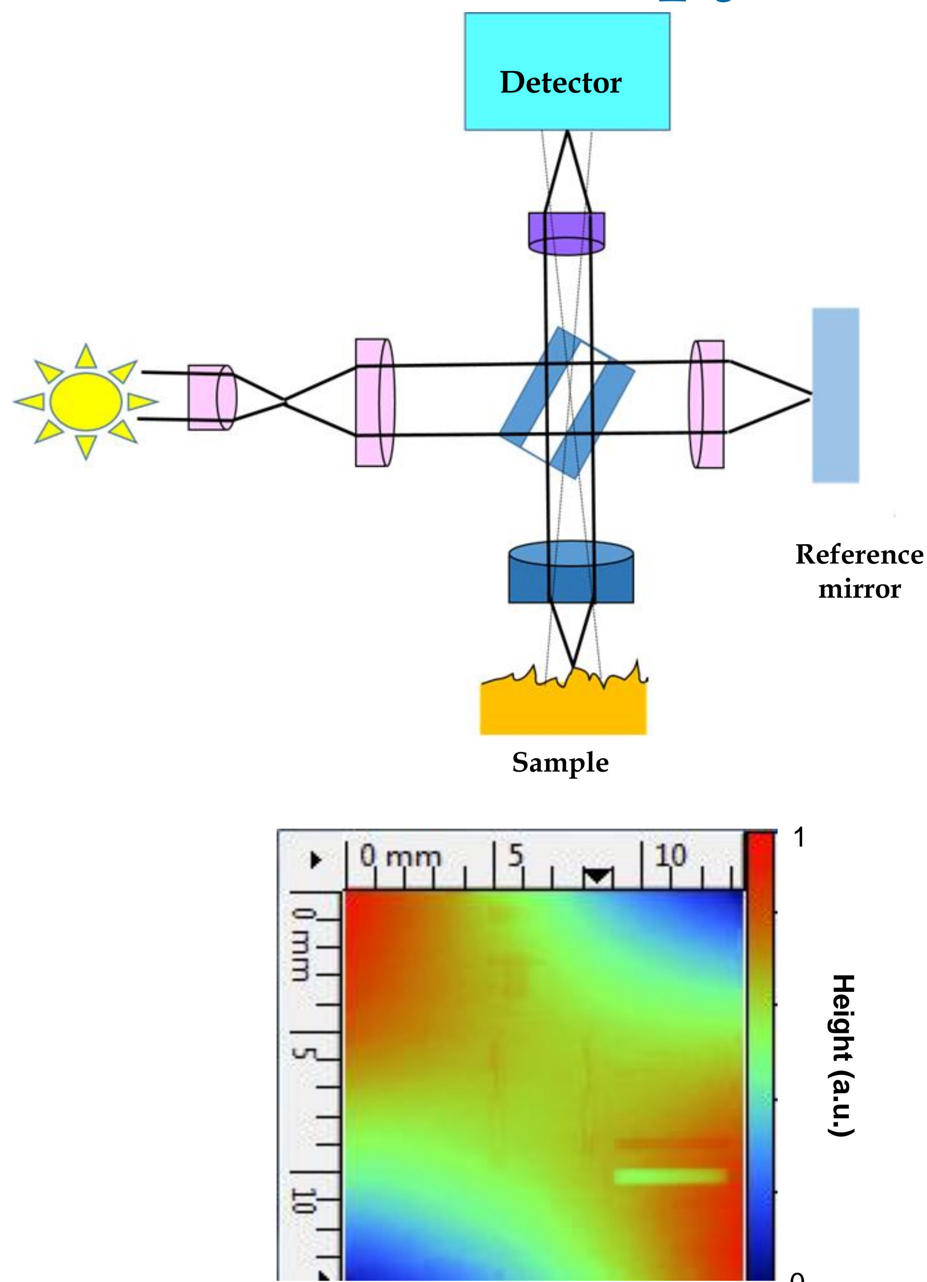


Figure 4: surface contributions to topography

Interferometry microscopy



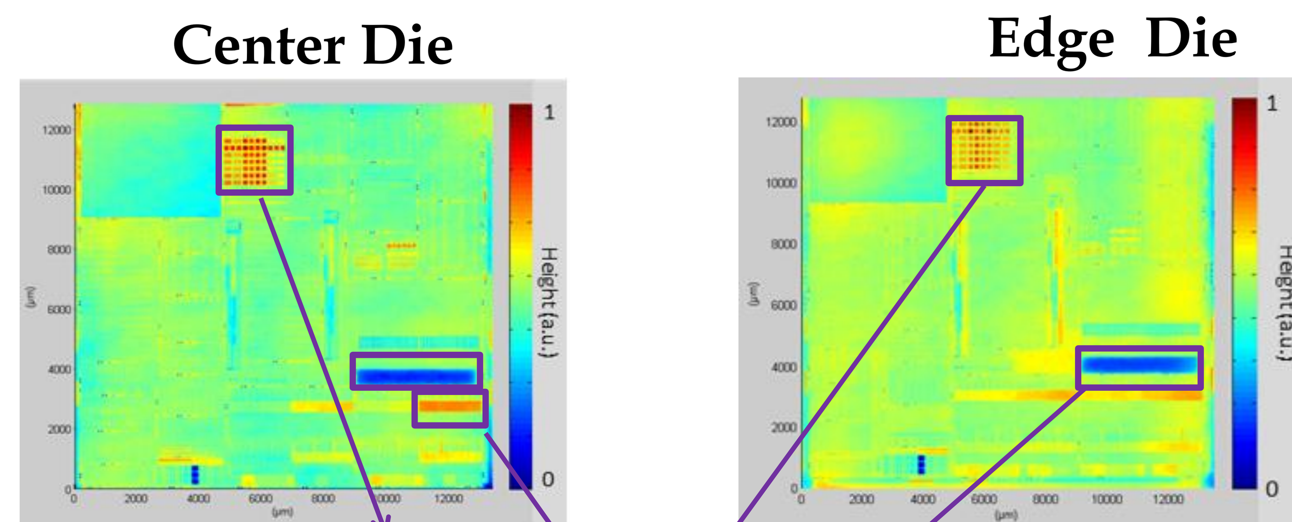
Interferometric Microscopy techniques have allow to characterize nanotopography at the die and wafer scale, using stitching and different lateral and axial resolution [3].

This new data give full information of the die topography, spatially resolved at µm level. The study shows that classical 2D profiles parameters are not enough to characterize this data and use it for improving CMP.

Results and discussion

Two types of wafers have been used to underline the general problem : Front End of line (at STI and PMD CMP) and Back end of line wafer with several metal layers for 28 nm.

BEOL CMP results



Potencial problematic zones

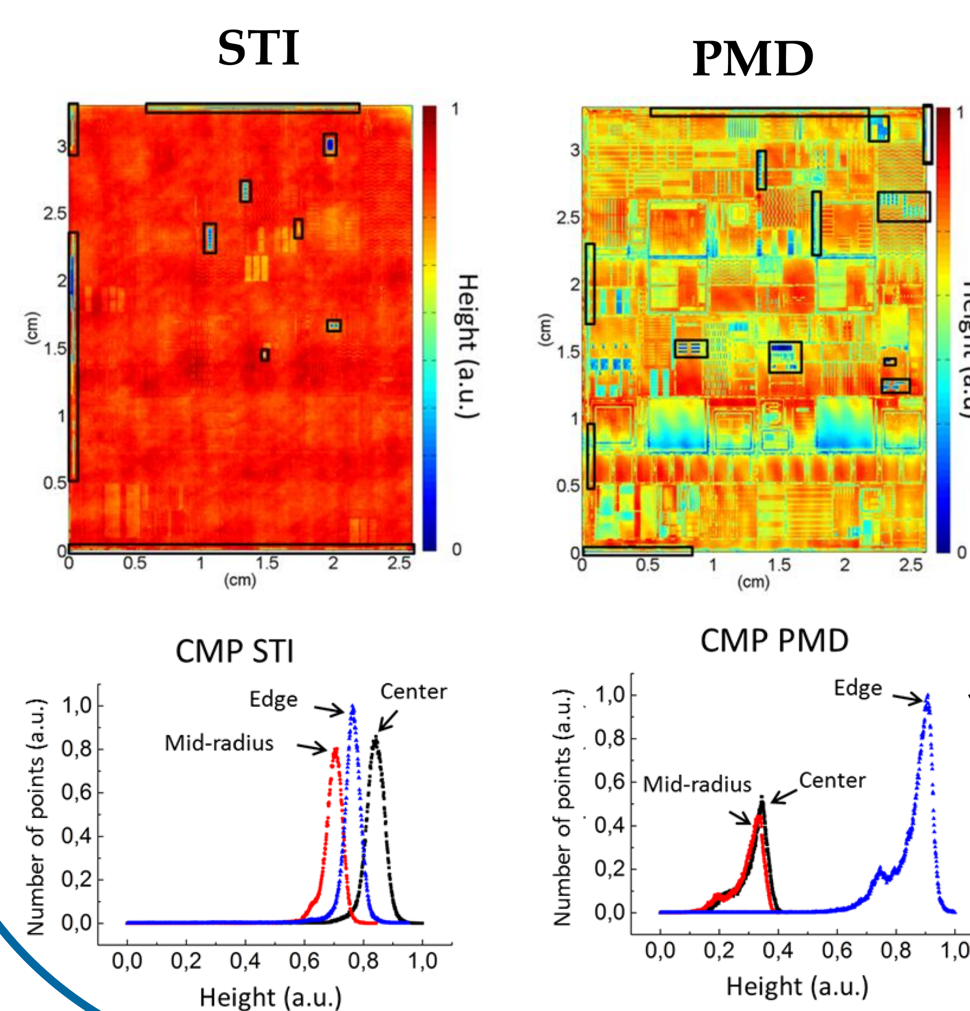
High resolution maps:

- Representative comparison inside and between dies

❖ Enable the identification of potential problematic zones in-die

❖ Enable die to die comparison: nanotopography contribution differences between the center and edge dies

FEOL CMP results



Height distributions display a signature of the process:

❖ **STI CMP: (one single population)**
Gaussian distribution → selective process → CMP efficient at die level

❖ **CMP PMD: (not a single population)**
a unique population can't be assumed → non-selective CMP process

* All values have been normalized

Experimental conditions

- ❖ Bucker Interferometer: Wyko NT9300
- ❖ Field of view: 2,4 mmx1,8 mm
- ❖ Vertical resolution : 1 nm
- ❖ Lateral resolution:3,6 µm
- ❖ Stitching mode used

Conclusion

- ➢ High resolution nanotopography data give new insights to CMP's efficacy analysis
- ➢ Nanotopography maps lead to :
  - ❖ Nanotopography information at die and wafer scales
  - ❖ Global in-die detailed information (not possible with profilers)
  - ❖ Detection of problematic zones
  - ❖ Height level distribution analysis at the die scale: a new way of analysis
- ➢ This kind of measurement and analysis would be useful for : 3D integration, 3D monolithic integration and substrate bonding

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MINATEC Campus | 17 rue des martyrs | F-38054 Grenoble Cedex

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2) P. Guguen et al, "Physics of direct bonding: Applications to 3D heterogeneous or monolithic integration", Microelectronic Engineering 87 (2010) 477–484
3) F. Dettoni et al. / Microelectronic Engineering 113 (2014) 105–108