Etch Endpoint detection of low open area contact by means of new CCD optical emission spectroscopy techniques developed with Jobin-Yvon.

CCD endpoint

CREMSI November, 13 – 14th

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Semiconductor ALTIS

Abstract

Dry etch is a critical step in semiconductors manufacturing. While new products and processes are continuously developed and improved, the technology becomes ever more complicated with the increase of the device density. End-point detection of low open areas presents a serious challenge for process monitoring.

In a joined effort, we developed a new generation of Multi Sensor Platform for fault detection, health monitoring and Advanced Process Control (APC). Based on innovative technologies like smart sensors, a unique software architecture including analytical methodology, and a sophisticated signal processing, this platform allows to satisfy all the needs of in-situ process control.

These slides describe the first results obtained for via etch process (open area from 1 to 10%) on leading edge products (0.18 µm-0.13 µm technology with copper backend) by using OES (optical emission spectroscopy) sensors as endpoint detection (EPD). All experiments were conducted on high density plasma oxide etcher tools and show excellent stability in high volume production.

Synopsis

- **ALTIS Semiconductor**
- **Multi sensor platform for APC (JY)**
- **Plasmascope used as Optical Emission Spectroscopy on Via etch**
  - Step 1 : Algorithm development
  - Step 2 : Recipe and endpoint optimisation
  - Step 3 : Endpoint algorithm validation
  - Step 4 : Robustness evaluation
- **Other application**
- **Conclusion**

ALTIS Semiconductor

2003 Essonne Nanopole

Infineon technologies

IBM

KLA Tencor Accelerating Yield

AIR LIQUIDE ELECTRONICS

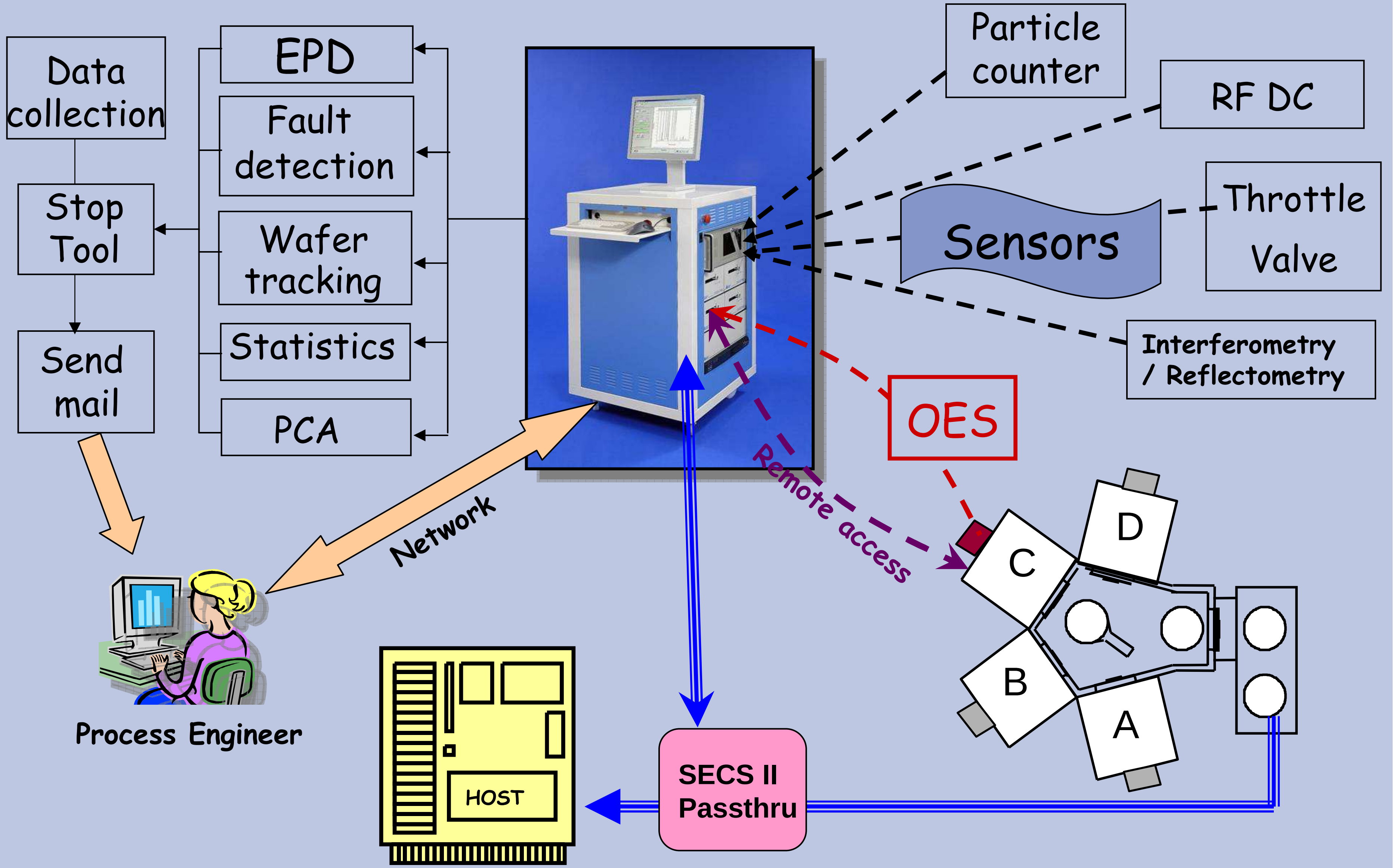
DU PONT DuPont Photomasks, Inc.

BOC EDWARDS

PROBEST UPSYS MECANOBLOC

Applications

Tool Integration / APC platform



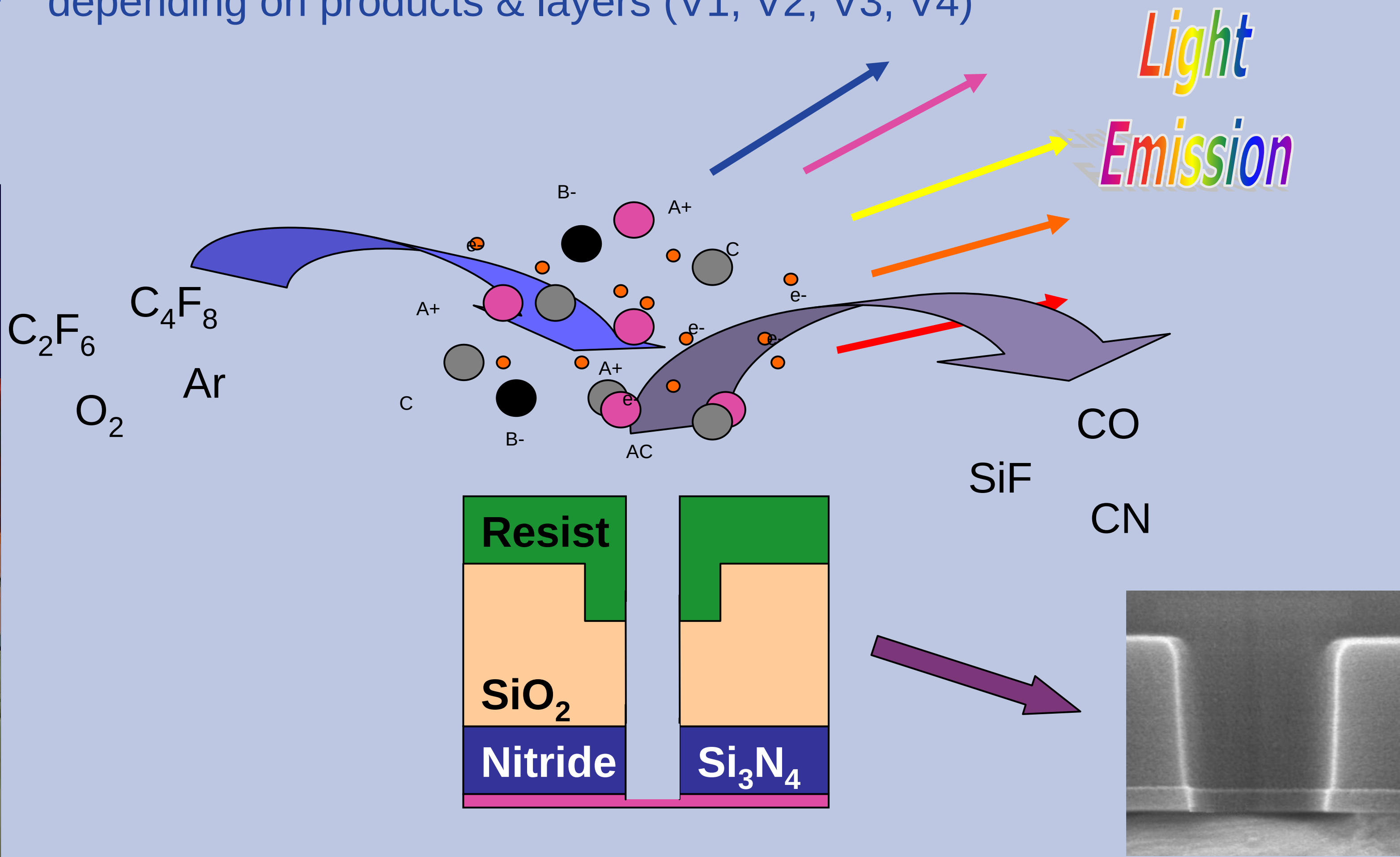
Major key points

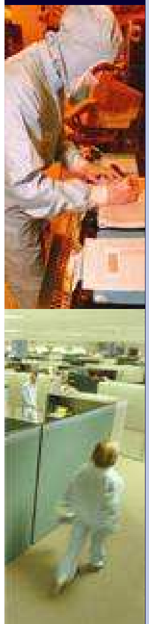
CCD endpoint

- **OES capabilities for plasma spectral analysis**
  - Integrated OES Library
  - **Full reprocessing**
  - Script, APC engineering
  - **Advanced mathematical spectrum analysis for finding EPD participating wavelengths : AUTOPATTERN**
- **Advanced ENDPOINT detection**
  - **Multi-wavelengths acquisition, arithmetical operations**
  - Filtering
  - New EPD algorithms
  - Sensitivity improvement algorithms
- **Production control capabilities**
  - Full database (SQL)
  - Statistics recipes
  - **Chamber health R2R control, fault detection, chamber health (AEC/APC management)**
- **User Friendly settings**
  - Quick recipe editor, LEGO block, help on line, one click action button
- **New interface capabilities**
  - **FAB communication through TCP/IP, SECS_Pass through, Email auto sender, platform for external tool sensors, distant access available (DB, recipes, reprocessing from Desktop)**

Application example : Via etch on .18 µm technology on HDP tool

Vx : .18µ : Open area ~ 1-2 % to 10 %
depending on products & layers (V1, V2, V3, V4)

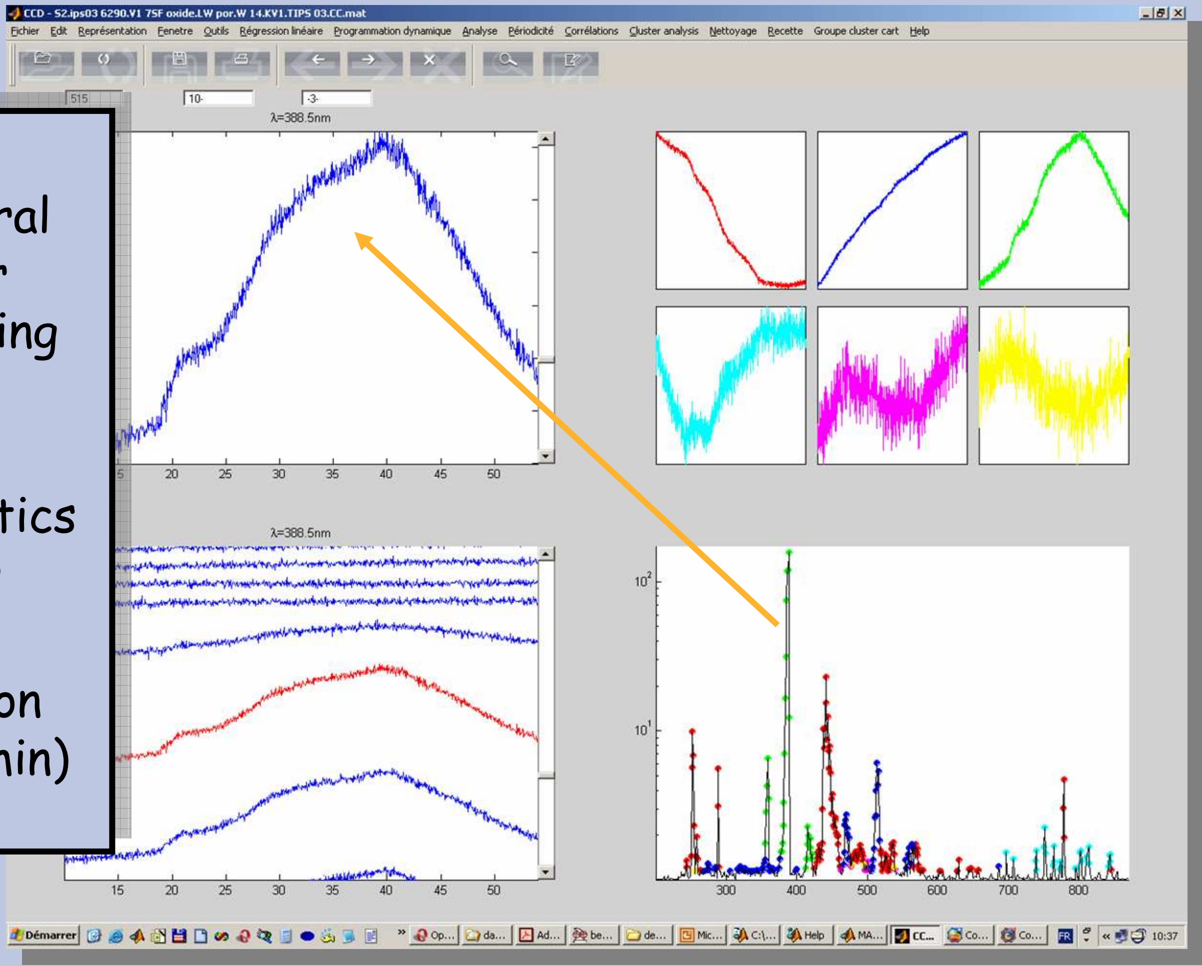


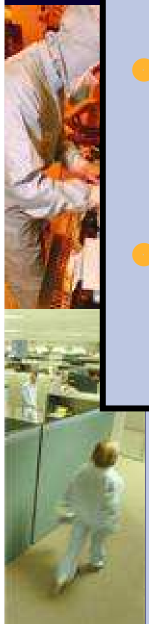


Step 1 : Algorithm development
> Spectra and clusterisation analysis

endpoint

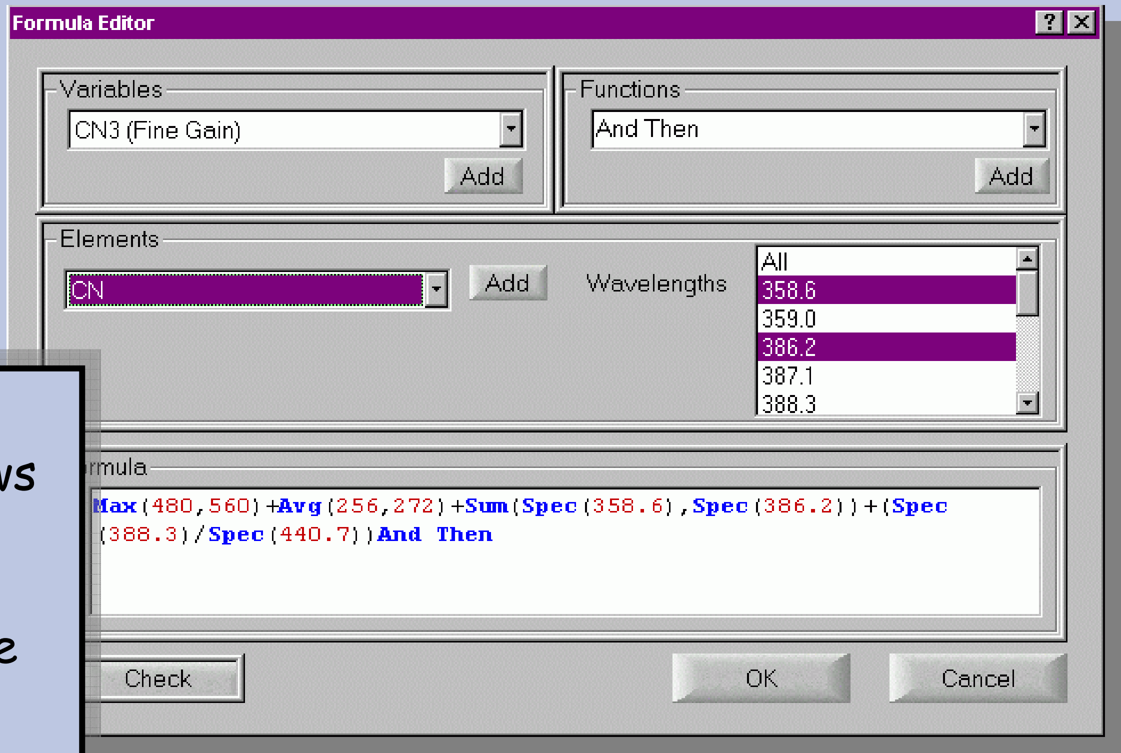
- Advanced multispectral spectrum analysis for finding EPD partitioning wavelengths clusterisation
- Show the set of kinetics by clusters of similar shapes
- Allows fast recognition of key patterns (< 1 min)





Step 1 : Algorithm development
> Recipe build up

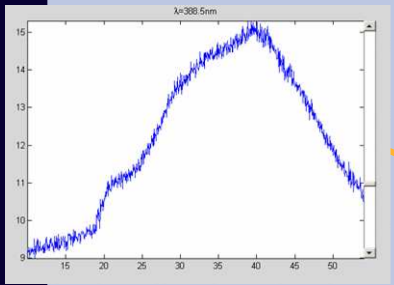
CCD endpoint

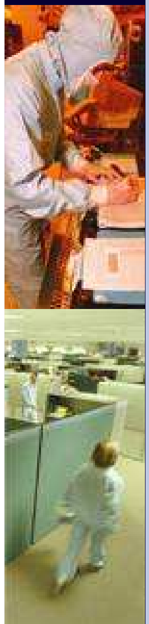


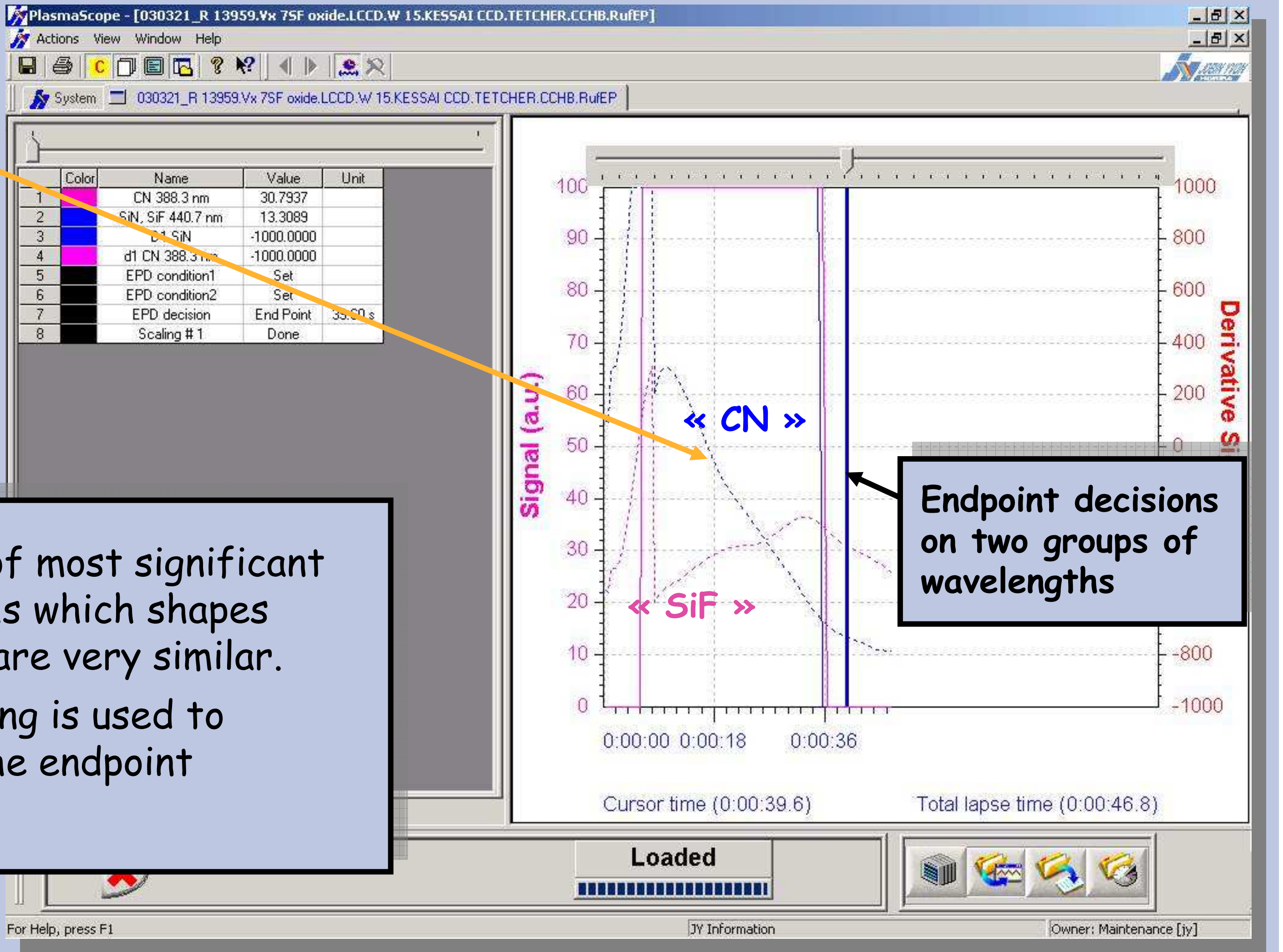
- The recipe editor allows to use mathematical, logical operations and advanced filters on the selected wavelengths

  >> high sensitivity algorithms

Step 2 : Recipe and EPD optimisation

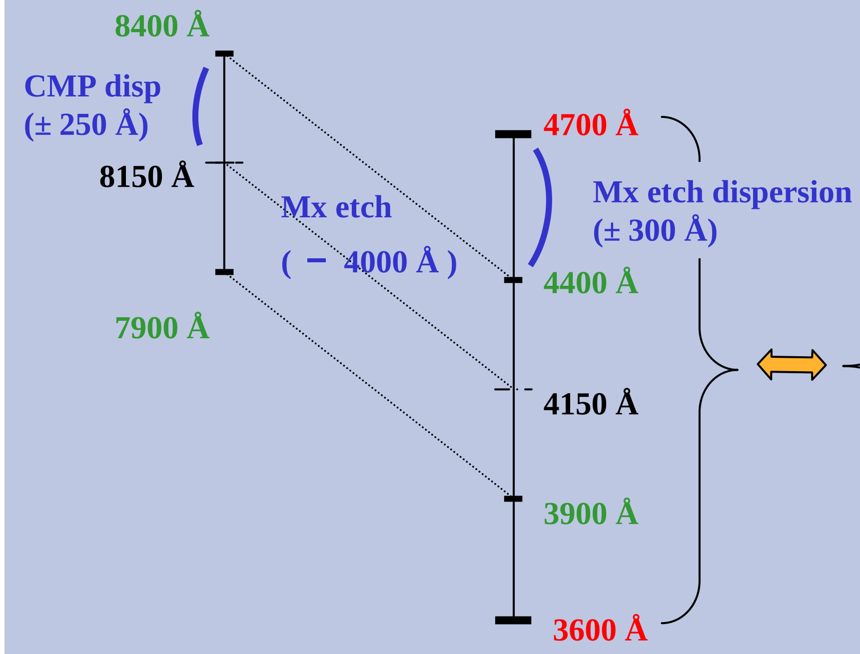


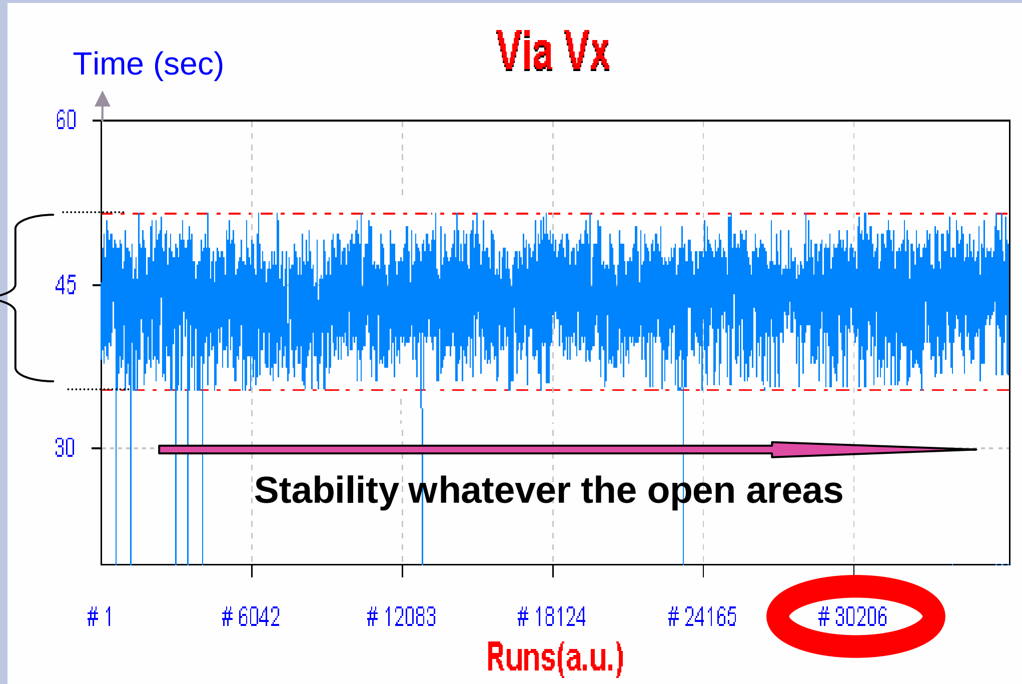


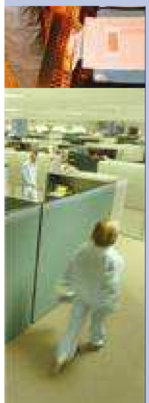


- Selection of most significant wavelengths which shapes variations are very similar.
- Reprocessing is used to optimise the endpoint algorithm.

Step 3 : Endpoint algorithm validation (1)



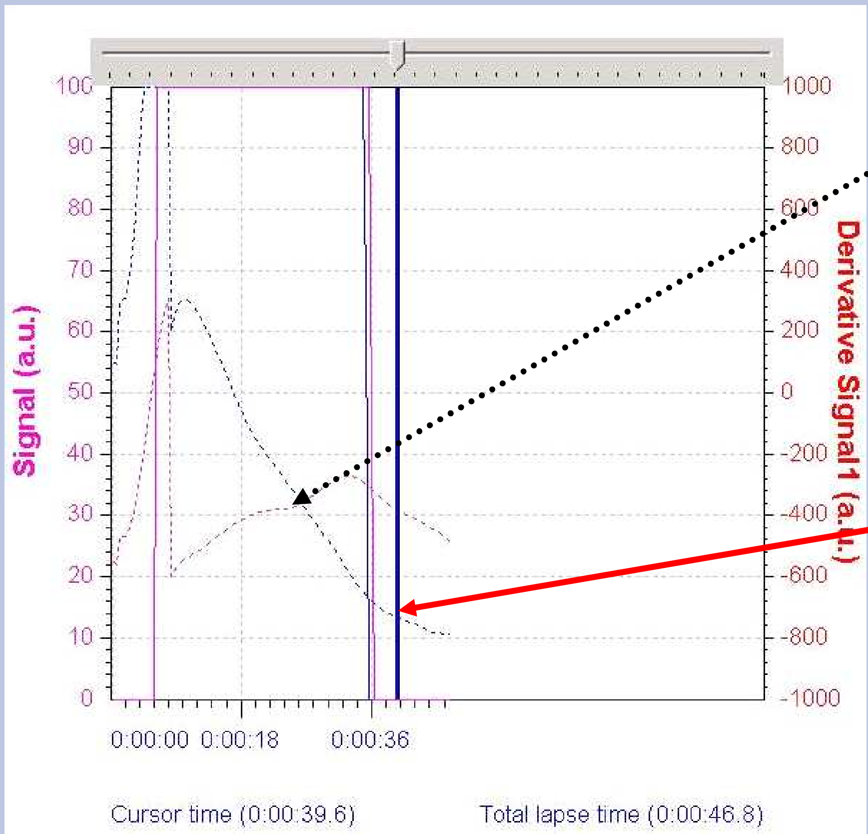


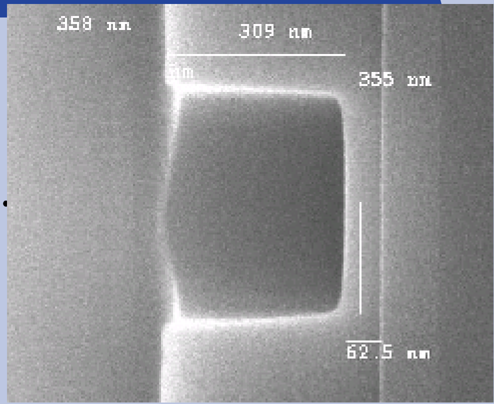


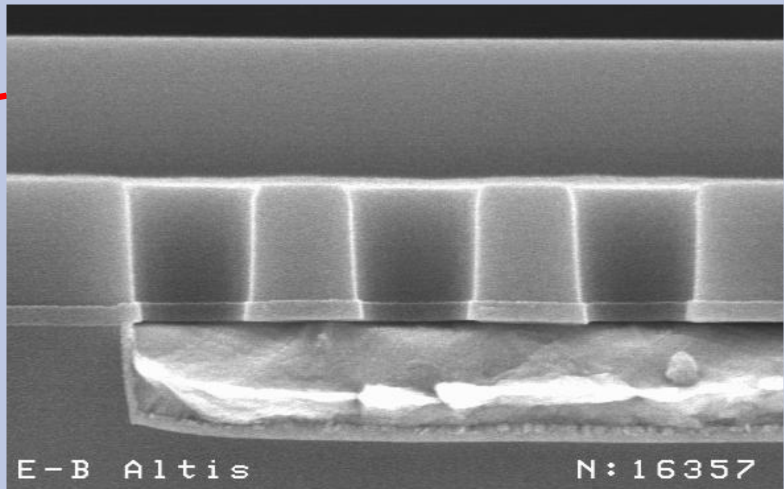
- CMP and Mx etches introduce oxide thickness variation (between 3600 and 4700 Å) which can explain an endpoint time variation of about 11 sec (if we consider an etch rate of 100 Å/sec)
- Moreover , we have to add the variation given by :
  - the effect of CMP and Mx non uniformity
  - the different open area (1 to 6%)

Step 3 : Endpoint algorithm validation (2)

CCD endpoint



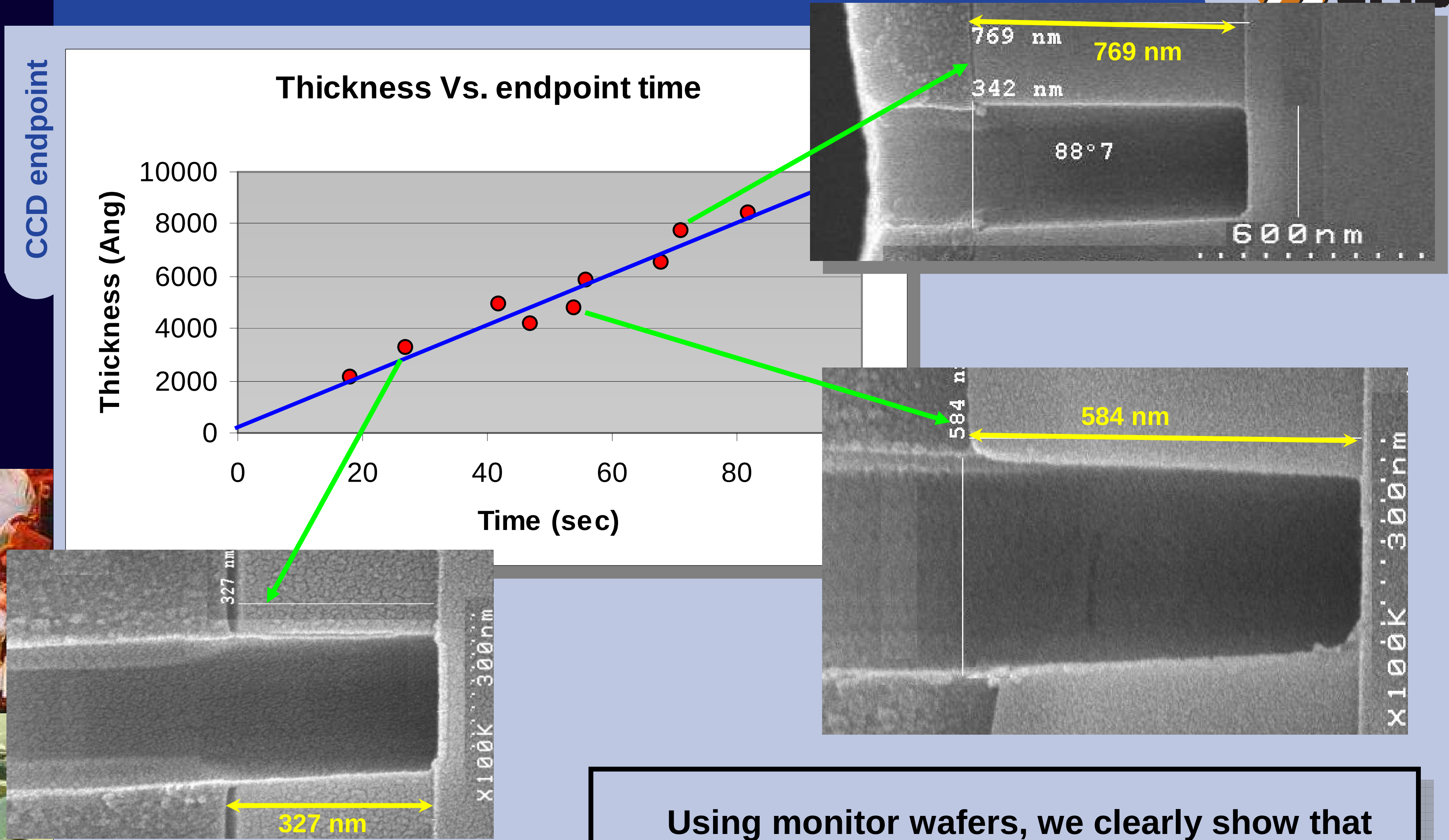


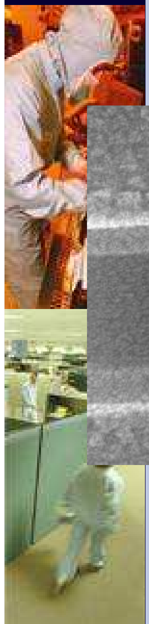


- SEM pictures show that we reach the interface only when the endpoint decision is complete

Step 3 : Endpoint algorithm validation (3)

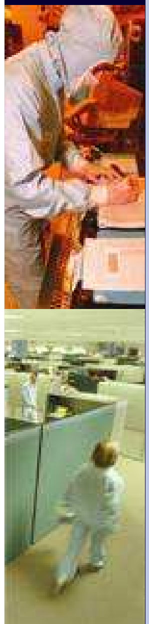
CCD endpoint



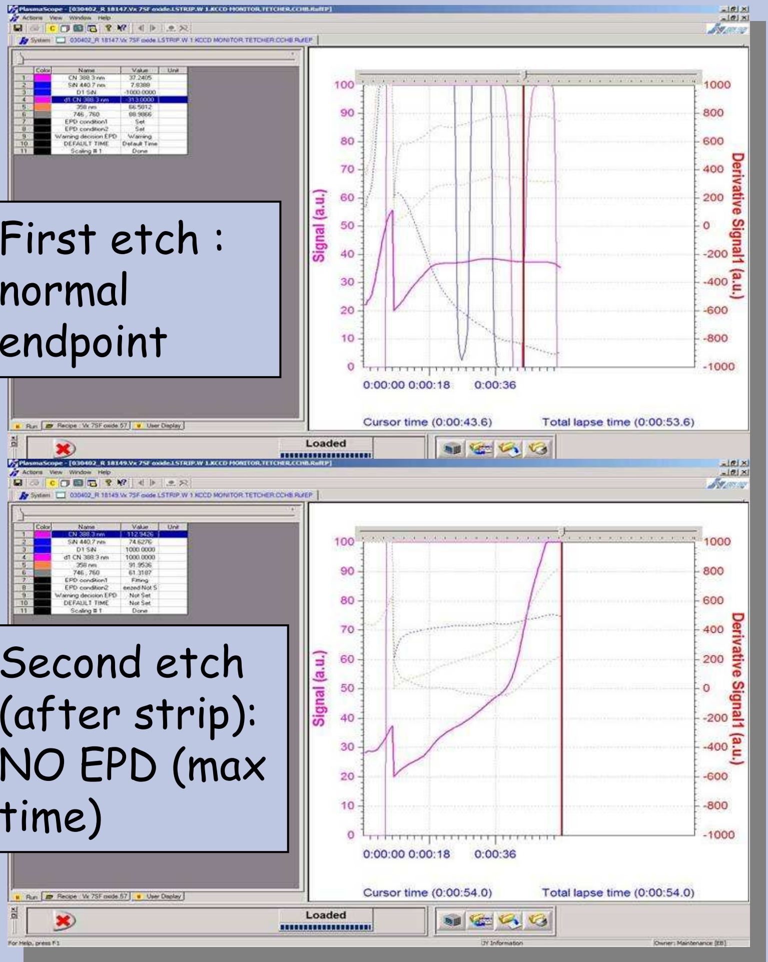


Using monitor wafers, we clearly show that our endpoint detection really happen when interface is reached

Step 4 : Robustness evaluation



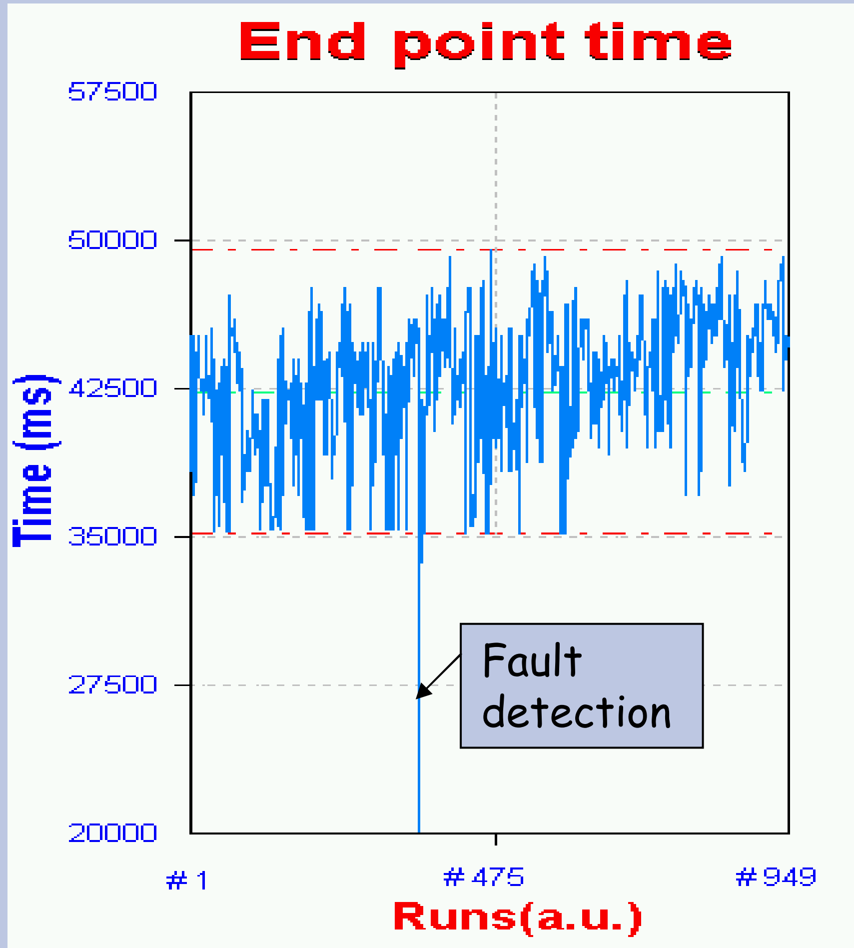
Example 1 : Double etch



First etch : normal endpoint

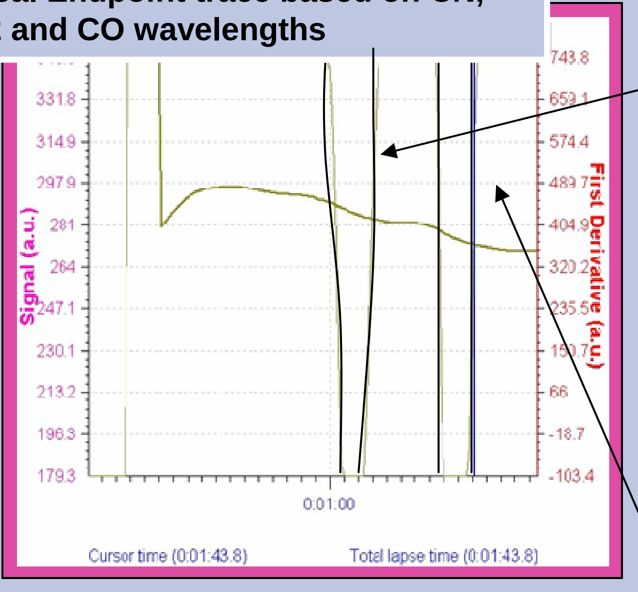
Second etch (after strip): NO EPD (max time)

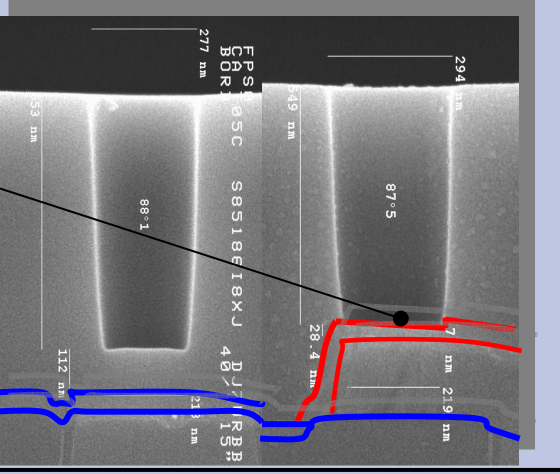
Example 2 : Missing exposure (only resist)



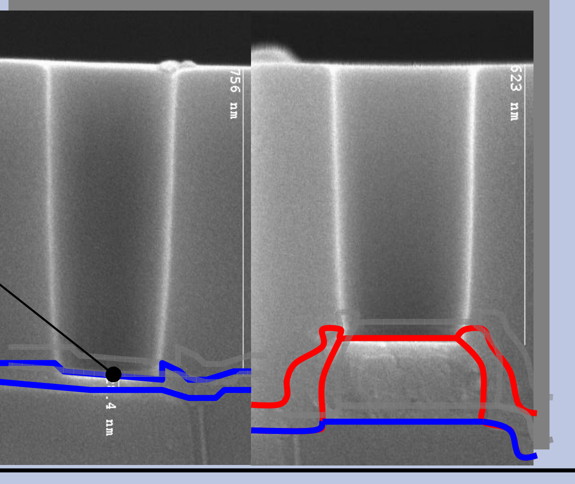
Other application

CA Optical Endpoint trace based on CN, SiF, CF2 and CO wavelengths

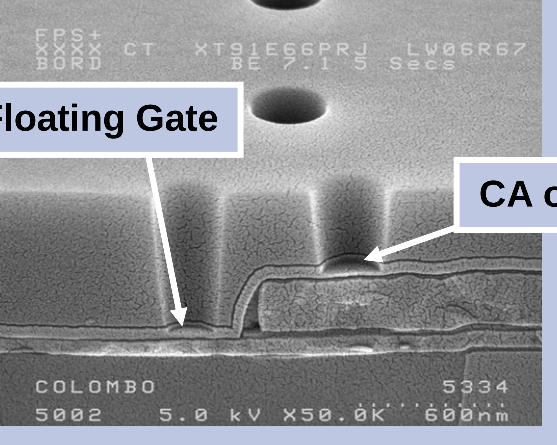




CA on GC (after first slope) cross section



CA on diffusion (after second slope) cross section



CA on Floating Gate

CA on GC

Conclusion

- A new platform was designed and developed for critical endpoint detections on which traditional methods were unsuccessful.
- It includes health monitoring capabilities to reduce tools downtime, optimise quality and secure wafers production.
- This platform was successfully implemented on tools running Via and Contact etch processes.
- The ability to interface most of the current etchers from any vendor (AMAT, TEL, LAM) was also demonstrated.
- Further developments are on-going in order to implement interferometry applications and additional faults detection methods.