

# METALLIC CONTAMINATION ANALYSIS OF 450 MM WAFERS USING VPD-DC-ICPMS AND LPD-ICPMS

Agraffel C<sup>1</sup>., Fontaine H<sup>1</sup>., Lardin T<sup>1</sup>., Enyedi V<sup>1</sup>., Noventa D<sup>1</sup>., Charlet B<sup>1</sup>., Delpu G<sup>2</sup>., Brillouet T<sup>2</sup>.

(1) Univ. Grenoble Alpes, F-38000 Grenoble, France - CEA, LETI, MINATEC Campus, F-38054 Grenoble, France  
(2) RECIF Technologies, 9 Rue des briquetiers, 31703 Blagnac, France  
Claire.agraffell@cea.fr

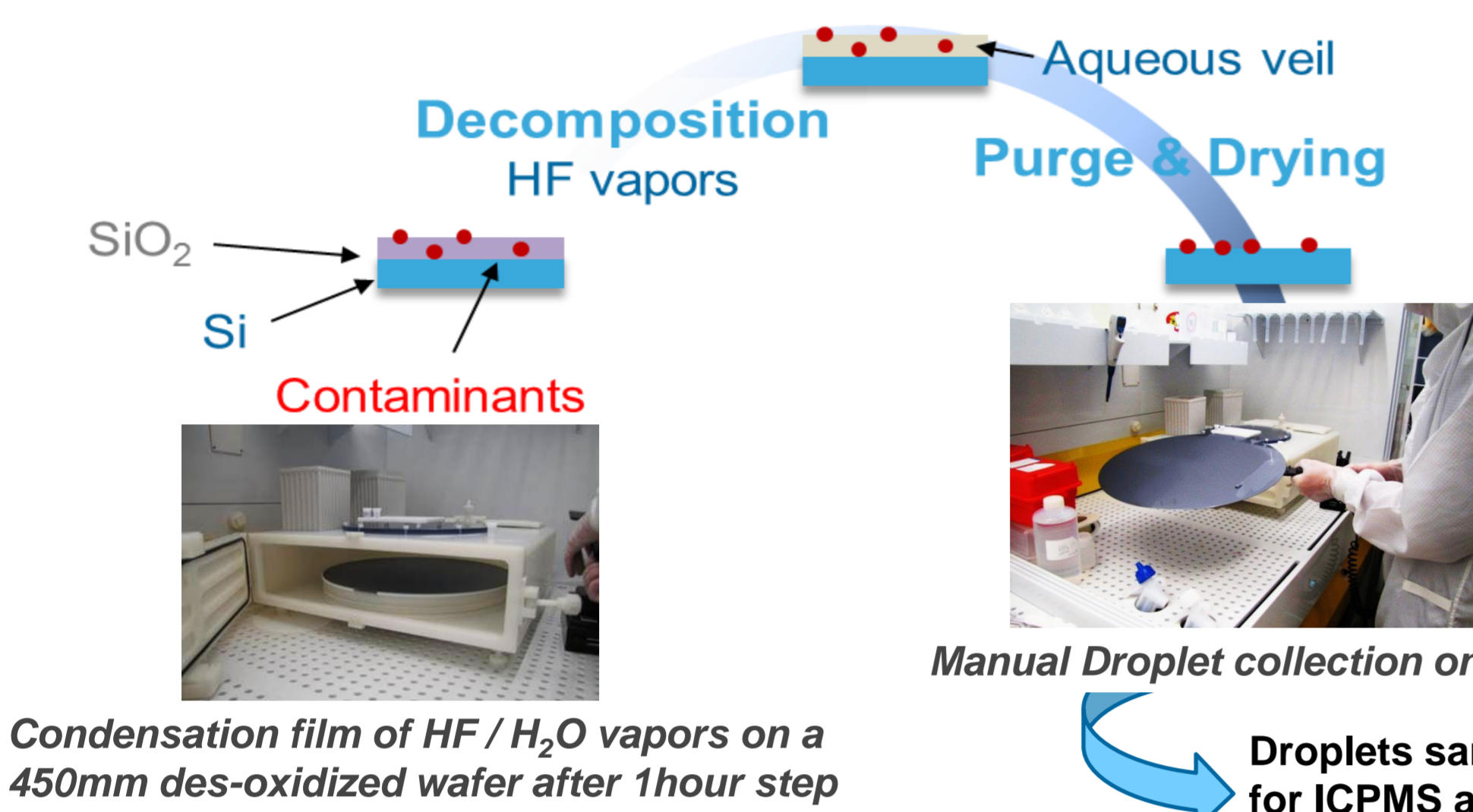
## INTRODUCTION

Among new developments (materials, architecture of devices, wafer size...), semiconductor technologies have to consider and integrate the control of metallic contamination because of the risks of device deterioration. The TXRF (Total X-Ray Reflection Fluorescence), is the common characterization of metallic contamination but with limitations in terms of sensitivity. An other solution involves to use an usual sensitive ( $1.10^7 - 1.10^8$  at/cm<sup>2</sup>) and accurate analytical techniques based on chemical collection followed by analysis with ICPMS (Inductively Coupled Plasma Mass Spectroscopy). Those techniques are implemented using manual collection to support and qualify the 450mm tool development.

## OBJECTIVES

- Implementation of VPD-DC (Vapor Phase Decomposition – Droplet Collection) -ICPMS for the detection of standard elements (Na, Mg, Ca, Al, Ti, Cr, Fe, Co, Ni, Cu, Zn...) and LPD (Liquid Phase Decomposition) -ICPMS for the detection of nobles metals (Au, Pt, Ag, Ru...) :
  - Manual methodologies (tool, parameters such as decomposition time, chemistry, volume, analysis...)
  - Evaluation of techniques (Collection efficiency, Detection Limits)
- Application to control and qualify a 450mm Sorter in terms of metallic contamination

### VPD-DC COUPLED TO ICPMS



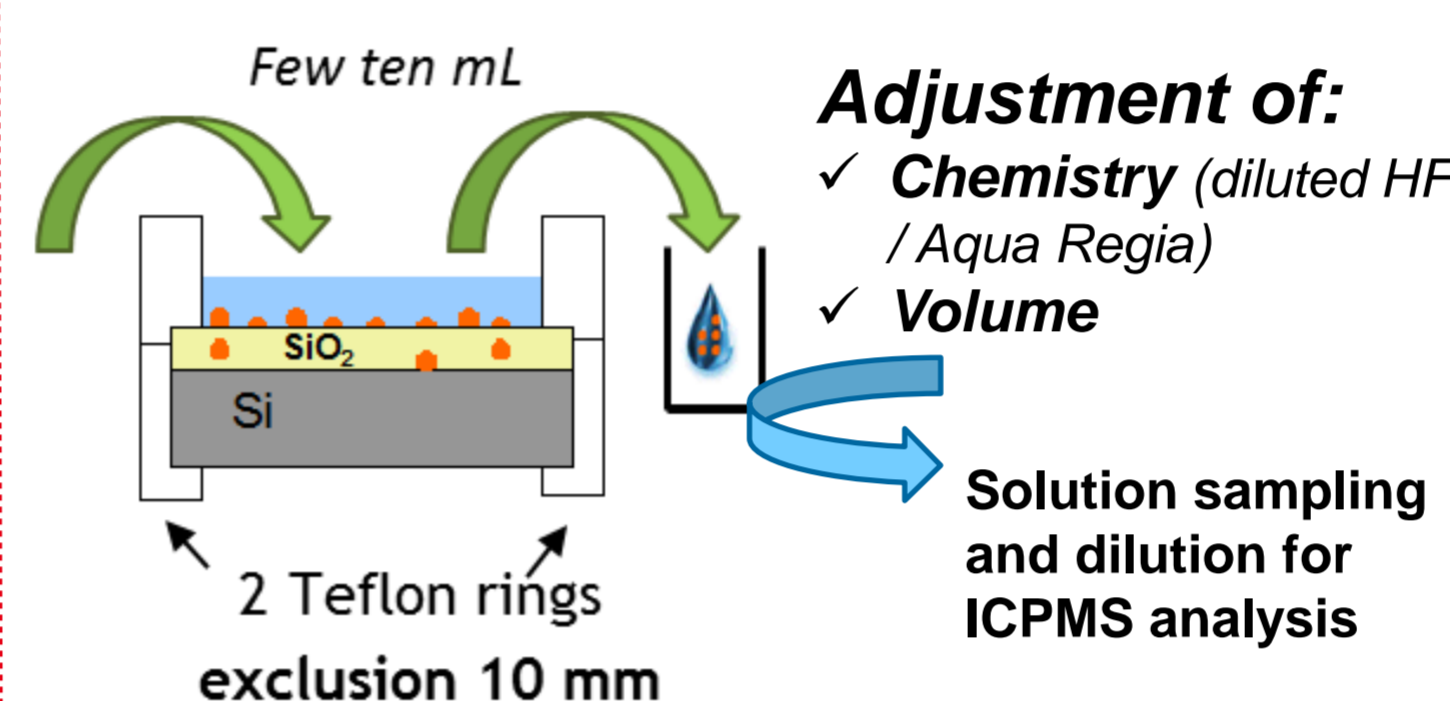
### EXPERIMENTAL IMPLEMENTATIONS

Design and fabrication of 450mm set-ups

- Adjustment of :
- Chemistry (HF / H<sub>2</sub>O<sub>2</sub>)
  - Volume
  - Scanning process

2 x scanning a half of wafer surface for each involving 2 VPD steps

### LPD COUPLED TO ICPMS



### EVALUATION OF TECHNIQUES

Calculation of Collection Efficiency with n>2

$$CE(\%) = \frac{\text{collection } 1}{\sum \text{collection } i}$$

Robust analysis when CE > 80%

Determination of Detection Limits

$$DL = 3\sigma$$

DLs << to ITRS specifications

## RESULTS

### VERIFICATION OF CEs

- Intentional contamination of a 450mm wafers with some representative elements : Na, Ca, Cu, Fe, Mo, Ni, Ti, W, Zn, Al using the spin-coating method
- Calculation of CEs results from 3 successive VPDs on the same contaminated wafer :

chemical elements	Al	Ca	Cu	Fe	Mo	Na	Ni	Ti	W	Zn
<b>Intentional contamination ~1.10<sup>11</sup> at/cm<sup>2</sup></b>										
VPD1 collection (1.10 <sup>11</sup> at/cm <sup>2</sup> )	3,2	1,1	0,62	3,1	1,5	3,7	2,5	1,2	0,75	2,8
CE (%)	96,7	96,2	61,4	95,4	95,5	100,0	95,9	95,8	90,9	96,7

- Al, Ca, Fe, Mo, Na, Ni, Ti and Zn > 95%
- W > 90%
- Cu around 60% as expected

Successful collection for all elements (except for Cu) = CEs equivalent to 300mm VPD-DC automatic system

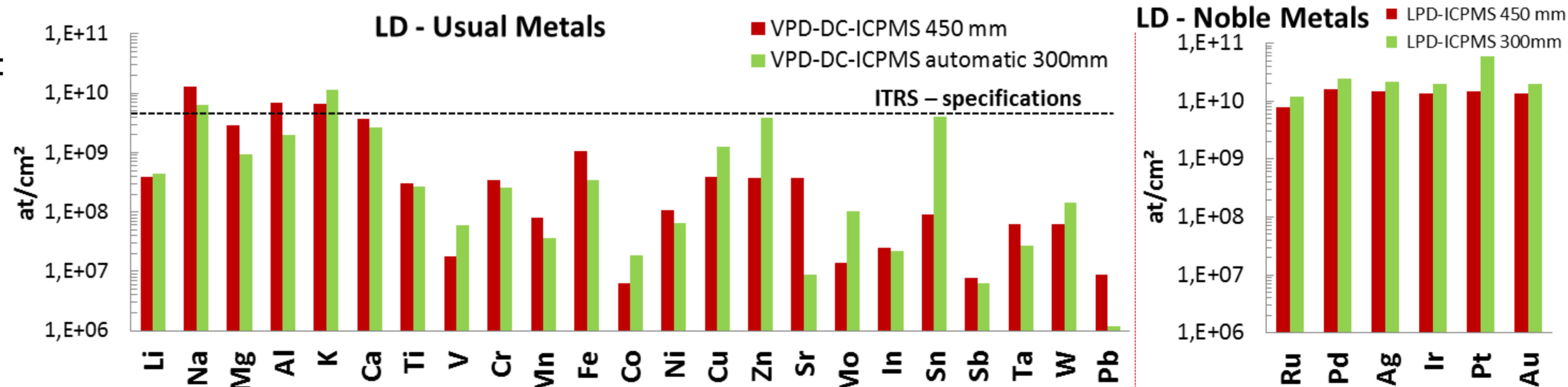
### EVALUATION OF DLs

4 VPD-DC- ICPMS and LPD-ICPMS are respectively done on 450mm wafers to estimate DLs of standard and noble metals :

- Range of 1.10<sup>6</sup> - 1.10<sup>9</sup> at/cm<sup>2</sup> for Li, Ti, V, Cr, Co, Ni, Zn, Sr, Mo, In, Sn, Sb, Ta, W and Pb
- Range of 1.10<sup>9</sup> - 2.10<sup>10</sup> at/cm<sup>2</sup> for Na, Ca, K and Al due to manual process

In agreement with stringent ITRS specifications

- Range of 4.10<sup>9</sup> - 2.5.10<sup>10</sup> at/cm<sup>2</sup> for all noble metals
- equivalent to LDs of 300mm wafers by LPD-ICPMS

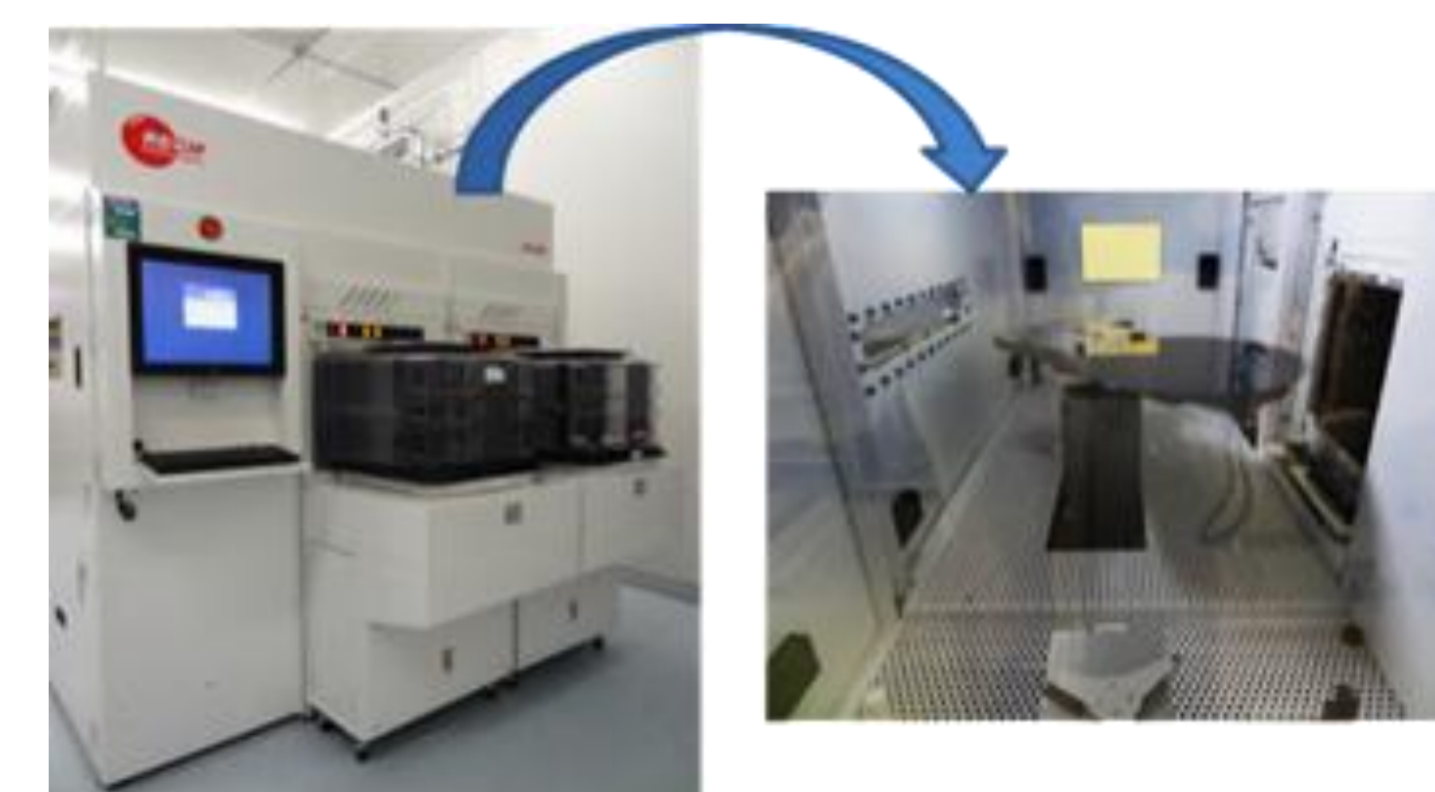
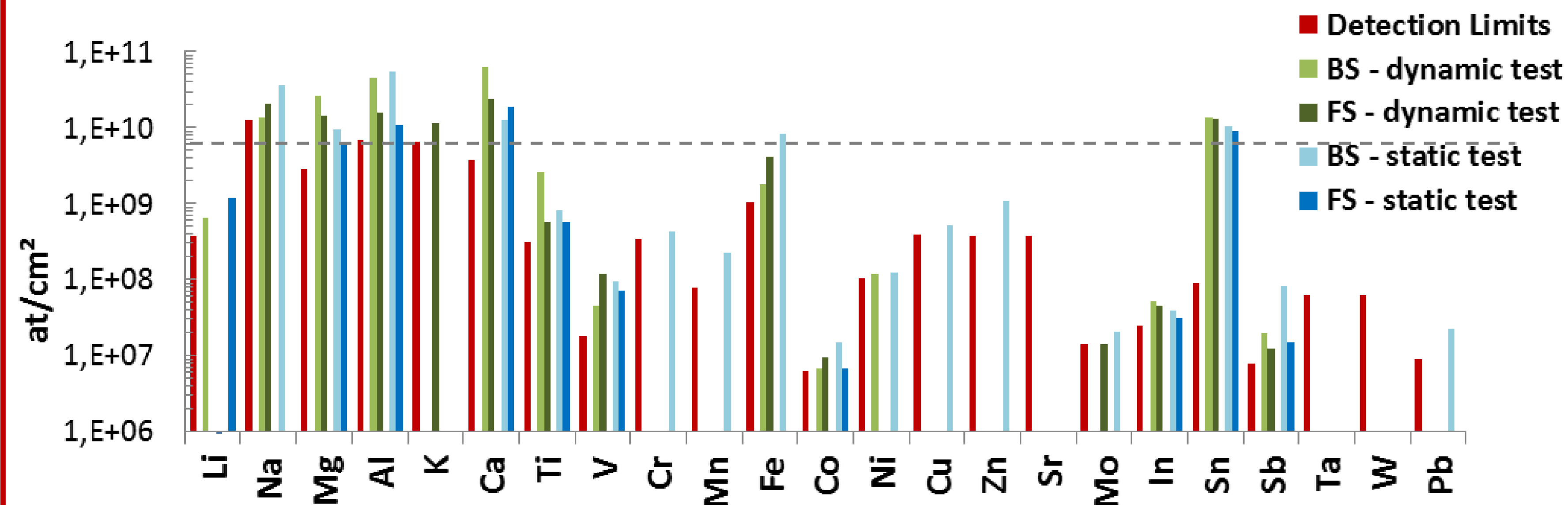


### APPLICATION TO METALLIC CONTAMINATION CONTROL

Developed VPD-DC an LPD – ICPMS used to qualify the cleanness of a 450mm sorter made by Recif with :

- « Static » control : 2 clean wafers – evaluation of transport contributions and environment
- « Dynamic » control : 2 clean wafers – evaluation of sorter by 500 entry/exit cycles inside the sorter

For each control = 1 wafer dedicated to Front Side and 1 wafer to Back Side control analysis



Usual elements by VPD-DC-ICPMS

- Low contamination levels close to DLs
- Only significant level of Sn for FS & BS (static and dynamic)
- Contamination added by connection to the sorter related to Sn soldering

Nobles metals by LPD-ICPMS

- No detection of noble metals for any control

## CONCLUSIONS & PERSPECTIVES

VPD-DC-ICPMS & LPD-ICPMS for 450mm wafers successfully implemented and qualified for the analysis of usual and noble metals respectively.

⇒ Low Detection Limits in range of 1.10<sup>6</sup> - 1.10<sup>10</sup> at/cm<sup>2</sup> according to ITRS recommendations and better than TXRF analysis

⇒ Demonstration of capabilities and performances required to support industrial 450mm development

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