

PPQ Analysis Real Challenge for a New Need

ppq *abbr.* Part-per-quadrillion. One in a million billions. Described in the Systeme International of Units [SI] by the prefix femto (10^{-15}).

1 ppt = 1,000 ppq. 1ppb = 1,000,000 ppq.

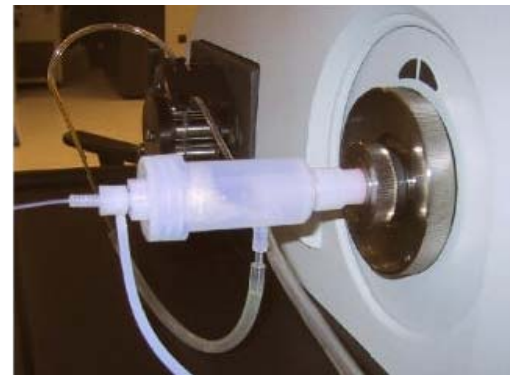
A need for lower detection limits

As semiconductor technology moves into production at the 90 and 65 nm nodes, the effects of trace contamination in process become more critical. This has been demonstrated in the industry recently by specific metal contamination of Ni and Ca at part-per-quadrillion (ppq) levels causing process concerns that were not observed with previous design rules. As a result, current state of the art part-per-trillion detection limits for deionized water and ultra-trace chemistries such as HF, H₂O₂, and NH₄OH are becoming insufficient for detecting these types of problems.

A real challenge

The Balazs R&D teams have developed new ways to accurately quantify metal contamination at these extreme trace concentrations, and can perform both sampling and analyses accurately and with excellent repeatability. A successful analysis at ppq is dependent on special considerations and handling throughout the lifetime of the sample, from initial sampling to sample preparation to the final blank and sample analysis. Examples of our level of care for an extreme trace sample are described below:

- Sample bottles are screened for purity and cleaned for 2 months with an etching solution.
- The sample is collected with a self-cleaning device to prevent contamination.
- The sample is concentrated up to 200X. Without contributing contamination!
- The sample is prepared (and analyzed) in duplicate as a quality control measure.
- Blank and standard solutions are made from extremely pure sources and diluted with Process grade DIW to lower background as much as possible.
- The actual sample is introduced into the ICP-MS with a home-designed system, the "muffler" (see picture), to help lower matrix effects.
- The final indication of our surety in this method is the spike recoveries performed at concentrations in the hundreds of ppq; all recoveries are in the 90-100% range.



The "muffler":
helping lower detection limit

Nickel and Calcium contaminations at ppq level were enough to cause process concerns, and had a material impact on yield.

PPQ Analysis Real Challenge for a New Need

All of these concerns and precautions are necessary to maintain sample integrity and avoid sporadic, extreme-trace contamination that can easily contaminate a ppq chemical to low ppt levels in the final analytical result.

An example of actual data is shown below for select elements with the ppq method. Duplicate results for each position are reported in units of ppt to show repeatability.

Sample	⁴⁰ Ca	⁴⁸ Ti	⁶² Cr	⁶⁸ Fe	⁶⁸ Ni
Position 1	<0.85	<0.15	<0.25	<0.50	<0.15
	<0.85	<0.15	<0.25	<0.50	<0.15
Position 2	2.25	<0.15	1.20	0.84	4.35
	2.46	<0.15	1.16	0.87	4.39

With these results we can demonstrate that contamination such as Ca and Cr at the 1 and 2 ppt levels are very real. To see if your process demands this type of trace analysis please contact your local account manager (see listing at www.Balazs.com) to help setup sampling and analysis.

Conversion Table

Name	Exp	ppb	ppt	ppq
		µg/kg	ng/kg	pg/kg
		ng/g	pg/g	fg/g
		µg/l	ng/l	pg/l
		ng/ml	pg/ml	fg/ml
micro [µ]	10⁻⁶	1,000		
	10 ⁻⁷	100		
	10 ⁻⁸	10	10,000	
nano [n]	10⁻⁹	1	1,000	
	10 ⁻¹⁰	0.1	100	
	10 ⁻¹¹	0.01	10	10,000
pico [p]	10⁻¹²	0.001	1	1,000
	10 ⁻¹³	0.000 1	0.1	100
	10 ⁻¹⁴		0.01	10
femto [f]	10⁻¹⁵		0.001	1
Assumes density of 1 (ppbv and ppbw are then equivalent.)				