Agilent Technologies

ION Pumps for UHV Systems, Cyclotrons Synchrotrons & Particle Accelerators

Mauro Audi , Agilent Vacuum Product

Cyclotrons 2022

ION Pumps
Agilent Technologies

1957-59

Varian Associates invents the first ION Pump

ION Pumps

Main choice for UHV systems, cyclotrons , synchrotron & particle accelerators

Why?

1. Closed pump

   Do not need any baking pump

   No contamination from the roughing line

2. No moving parts

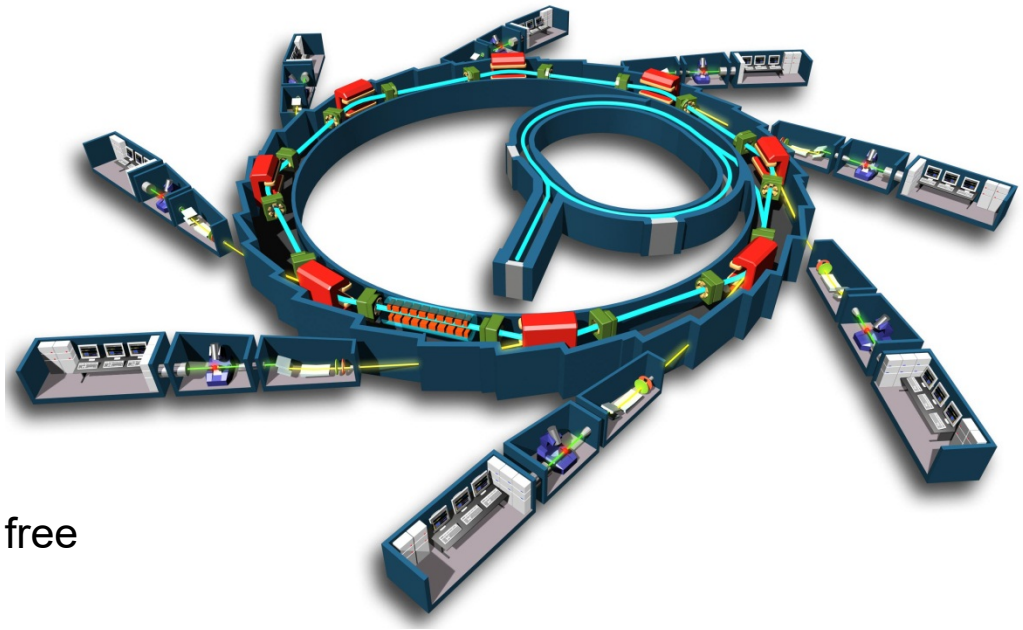
   There is no rotation or moving parts

3. No lubricant

   There are no oil or solvents and is fully contamination free

4. Can withstand air inrush or improper use

   Maintenance free, High reliability

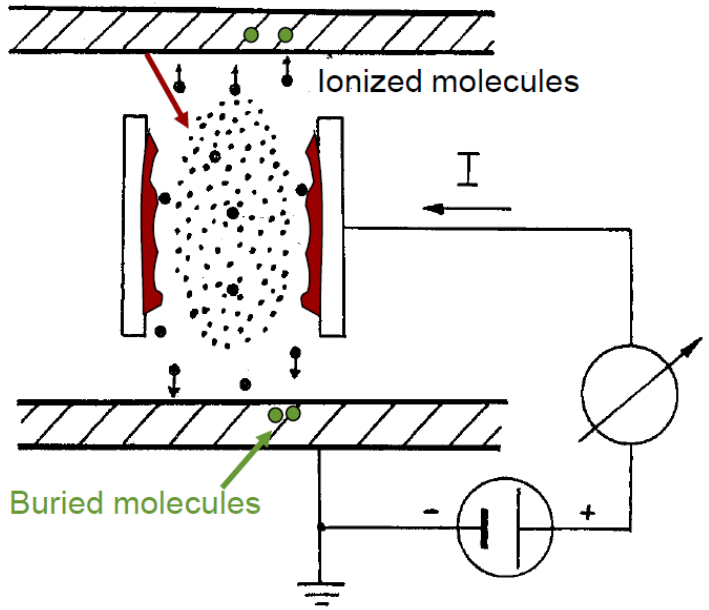


ION Pumps

Basic Pumping Mechanism

Pumping principle:

- Plasma discharge in crossed electric and magnetic field act as an electron trap
- Ionizing collision between electron and gas
- Ion bombardment of titanium cathode
- Some ions diffuse into the cathode (pumped)
- Sputtering of chemically active Ti film on anode
- Neutral Gas molecules stick to Ti film (chemisorption) and are buried in the anode (main pumping)
- Ion pumps do not pump only ions at the cathode , but mainly neutral molecules at the anode



ION Pumps

Basic Pumping Mechanism – Noble gases

- Ion pumps do not pump only ions at the cathode,but mainly neutral molecules at the anode
- This works only for all active (getterable) gases
- Noble gases do not react with Ti film
- No chemisorption of neutral molecules
- Alternative pumping method needed
- Some ion bombarding the cathode are neutralized and reflected
- They maintain enough energy to be physically implanted into the anode
- They will then be covered by the sputtered Ti film on the anode
- It is a physical burying, not a chemical reaction
- For this reason , pumping much less efficient than for getterable gases

ION Pumps

DIODE ION PUMP

Very limited Noble Gases pumping , both speed and capacity

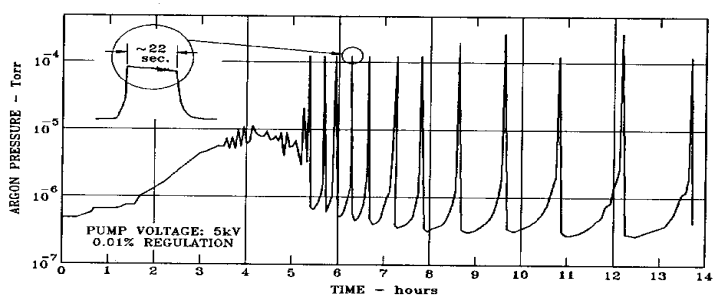
Low percentage of Ions are reflected and implanted into the anode

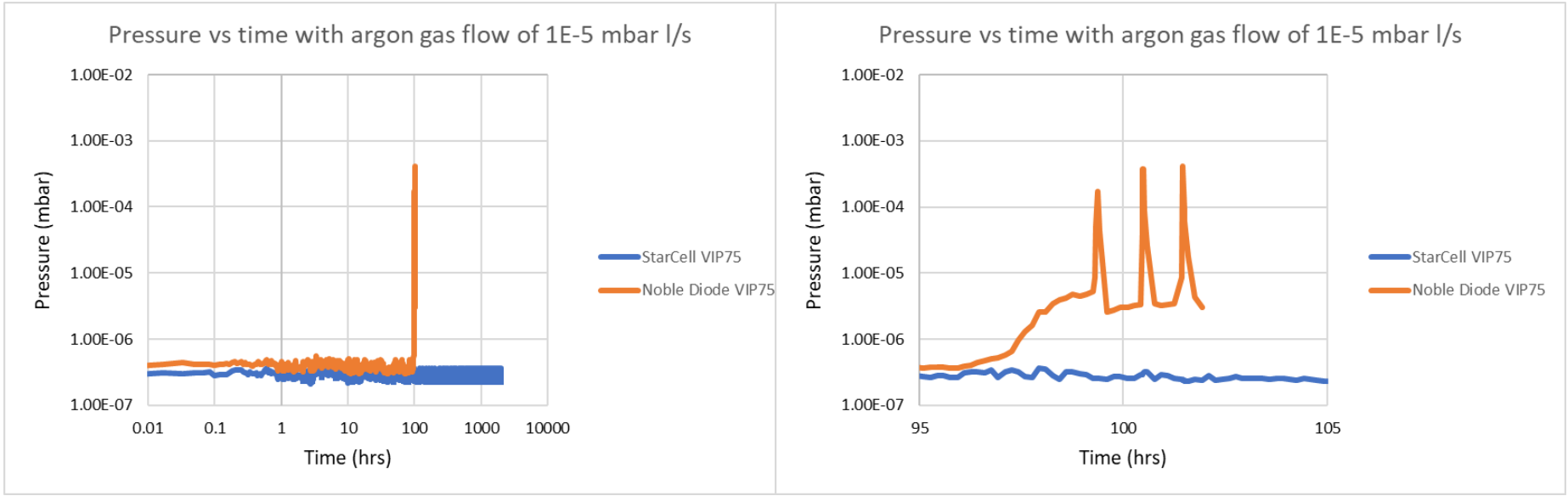
Noble gases are only temporarily pumped at cathode

Limited Argon capacity means :

	Pure Argon	Air (1% Ar)
10 E-5 mbar		8 days
10 E-6 mbar	20 hours	3 months
10 E-7 mbar	8 days	2.5 years
10 E-8 mbar	3 months	25 years
10 E-9 mbar	2.5 years	

Noble Gases Instability





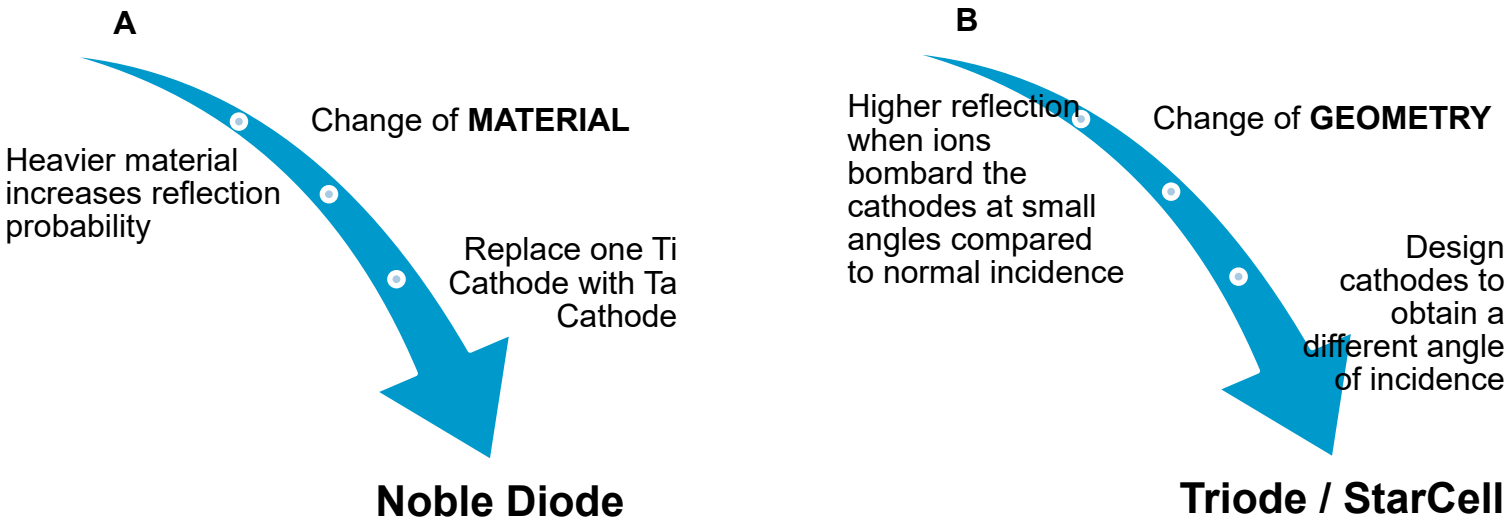
ION Pumps designe for Noble Gases pumping

Different types of pump: Diode, Noble Diode and StarCell

Improve the number/probability of Noble Gas ions reflection vs implantation after bombarding the cathode

After being reflected, they will be physically buried into the anode (no chemical interaction)

Two different approaches to modify Diode to obtain this result:



Both solutions do improve the pumping speed and stability for noble gases

ION Pumps

Noble Diode & StarCell vs Diode

Noble Diode vs Diode

- Much lower capacity and speed for H2 (Ta vs Ti)
- Lower speed for all getterable gases such as N2, CO, CO2 (Ta vs Ti)
- Improved stability for Noble Gases (one order of magnitude)
- Argon speed up to 15% 20% of Air Pumping speed vs 5% for a Diode

Starcell vs Diode

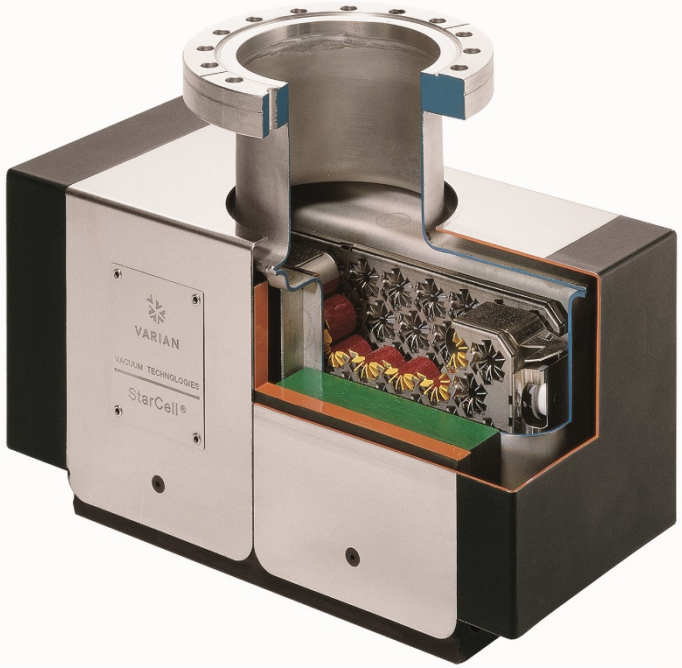
- Lower speed for all getterable gases (N2, CO, CO2)
- Comparable speed for Hydrogen (Ti vs Ti)
- Improved stability for Noble Gases (two orders of magnitude)
- Argon speed up to 35% 40% of Air Pumping speed vs 5%
- When only getterable gases must be pumped , Diode is still the best choice

ION Pumps

StarCell vs Noble Diode

- Much higher capacity for H2 (one order of magnitude)
- Similar speed for all getterable gases (N2 , CO , CO2)
- Higher stability for Noble Gases (one order of magnitude)
- Higher speed for Noble Gases (almost double , up to 40 % vs 20% of Air)

- When Noble gases must be pumped , StarCell is the proper choice



Agilent Technologies

ION Pumps
Manufacturing

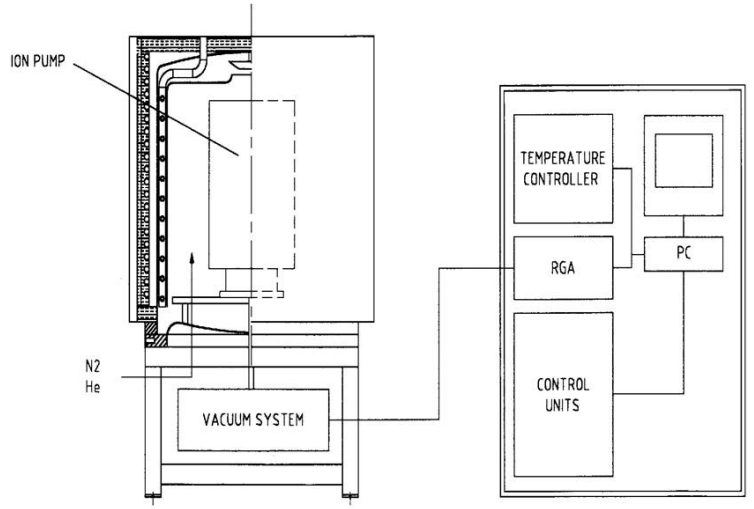
- In order to reach UHV , outgassing / cleanliness is even more important than pumping speed
- The ion pump element must be the cleanest surface exposed to vacuum , because its outgassing is due to both thermal and bombardment induced effect
- The cathode surface will eventually be removed (sputtered): therefore not only the surface , but the bulk too must be hydrogen free
- Ion pump element is “vacuum fired”

  2 hours @ 750 °C , at 1*E-5 mbar

- Then, the complete pump is processed under vacuum at 450°C

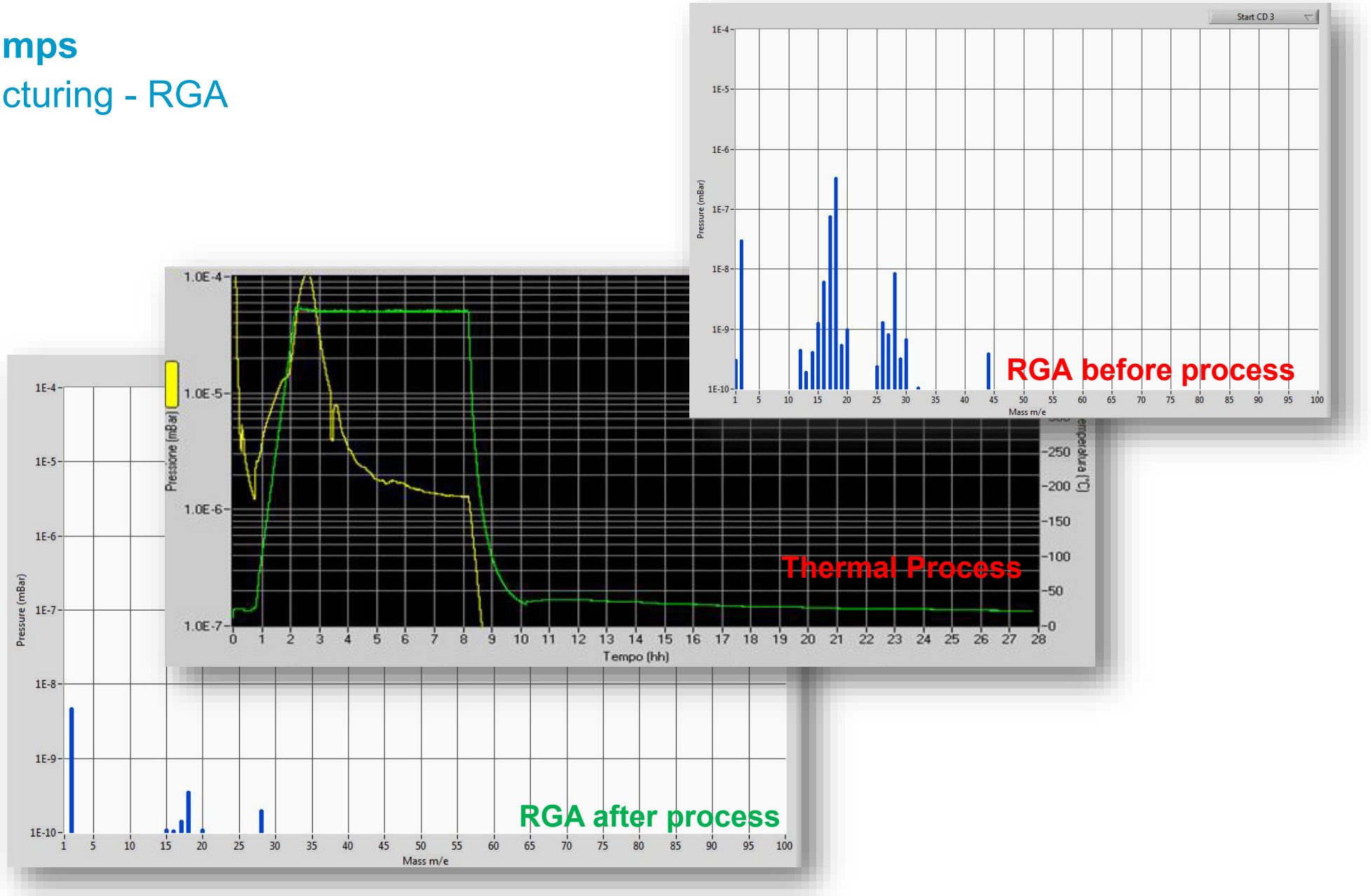
ION Pumps
Manufacturing

- Pumps are individually processed
- Residual gas analysis for each pump
- Individual records of each pump (outgassing , spectra…)
- Pumps are processed in nitrogen atmosphere to prevent external oxidation (no more beadblasting needed)
- Pumps can be leak-checked at high temperature (Helium instead of Nitrogen)
- Vacuum performance are much more repeatable



ION Pumps

Manufacturing - RGA



Agilent Technologies

Thank you for your attention !