



Characterisation of sputter-ion pumps to be used in combination with non-evaporable getters



Tommaso Porcelli ^{a, b, *}, Fabrizio Siviero ^b, Gero Antonio Bongiorno ^b, Paolo Michelato ^c, Carlo Pagani ^{a, c}

^a Dipartimento di Fisica, Università degli Studi di Milano, Via Celoria 16, 20133 Milano, Italy

^b SAES Getters S.p.A., Viale Italia 77, 20020 Lainate, MI, Italy

^c INFN-LASA, Via Fratelli Cervi 201, 20090 Segrate, MI, Italy

ARTICLE INFO

Article history:

Received 16 July 2015

Received in revised form

5 October 2015

Accepted 6 October 2015

Available online 14 October 2015

Keywords:

Sputter-ion pumps

Non-evaporable getters

UHV

ABSTRACT

The pumping behaviour of sputter-ion pumps (SIPs), as a direct result of their underlying pumping mechanisms, is heavily influenced by several factors, including operation pressure and composition of the residual gas being pumped. Depending on their pumping history, SIPs can be thus characterised by transient phases in which some gases are released prior to the attainment of equilibrium between pumped and re-emitted species.

In recent years, the feasibility of innovative vacuum pumps, based on the combination of SIPs with non-evaporable getter (NEG) technology, has been demonstrated; the optimisation of this coupling requires in-depth characterisations of SIPs, thus entailing the fine tuning of new specific testing procedures, which should flank and integrate the consolidated practice for SIP performance assessment. In this paper, some examples of the characterization of small SIPs are reported, in particular showing how the performances for Ar and CH₄ can be evaluated in view of the synergic coupling with NEGs.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Sputter-ion pumps (SIPs) are a well-exploited technology, dating back to the late 1950s [1], for the attainment and maintenance of high vacuum (HV) and ultra-high vacuum (UHV) conditions (*i.e.*, pressures lower than 10⁻¹ Pa and 10⁻⁷ Pa, respectively) in several technological applications.

Pumping mechanisms of SIPs involve several competing chemical and physical effects and are different for different gases; the overall pumping speed of a SIP is thus dictated by the balance between ions adsorbed at the electrodes and released from them.

Pumping speed of SIPs is not constant but varies over their range of working pressures. It usually increases from lower pressure until about 10⁻⁴ Pa, then it starts to decrease as pressure keeps growing, due to the increasing density of charged and non-charged species in the plasma and to gas reemission, which is caused by power dissipation and consequent pump overheating [2].

The measurement of their performance, in terms of ultimate

pressure and pumping speed, is regulated by an international standard issued by ISO/DIS [3]. According to this standard, N₂ should be used as test gas when measuring pumping speed, which should be determined with the known-conductance method [4] for pressures ranging between the lowest possible value (at least 10⁻⁶ Pa) and 10⁻³ Pa; pressure should be progressively increased in steps and it is necessary to wait each time until equilibrium conditions are established. The evolution of saturated pumping speed shall be plotted as a function of pressure; the maximum value shall be quoted as the nominal pumping speed of the SIP, specifying its corresponding pressure.

Several applications, however, pose strict constraints in terms of design, size, and weight of the pumping elements, thus limiting the feasibility of vacuum systems relying only on SIPs, especially if high pumping speeds are necessary. In order to fulfil these requirements, novel combination pumps based on the synergic coupling of a small SIP with a non-evaporable getter (NEG) cartridge have been recently studied and successfully developed [5]. This innovative configuration allows the NEG to be the primary pumping system, while the SIP is tasked only with removing the so-called non-getterable gases (*i.e.*, noble gases and hydrocarbons).

The optimisation of this coupling and of its synergic

* Corresponding author. SAES Getters S.p.A., Viale Italia 77, 20020 Lainate, MI, Italy.

E-mail address: tommaso_porcelli@saes-group.com (T. Porcelli).

mechanisms requires an in-depth characterisation of both its components. It follows that, as these two technologies are combined, the testing procedure for SIPs should line up with that for NEG. In particular, all the phenomena which might cause desorption from the pump (e.g., Ar instability, cracking of molecules and regurgitation of previously-sorbed gases), need to be taken into account in view of the coupling with a NEG element, in order to correctly evaluate the synergetic mechanisms which determine the performance of the combination pump.

In this perspective, here we propose a new approach aimed at effectively testing the performance of a SIP in view of its combination with a NEG cartridge, beyond the conventional method adopted to characterise SIPs.

Several small SIPs (with nominal pumping speeds for N₂ ranging between 5 and 10 l/s) have been chosen as test-vehicles and thoroughly tested according to a standard practice (former ASTM F798-97) which was specifically conceived for the determination of pumping speed and sorption capacity of NEG pumps [6]. In compliance with these guidelines, pumping speed of SIPs for a specific gas should be measured at constant pressure (again using the known-conductance method) and plotted as a function of the sorbed quantity of gas (expressed in Pa·l). Each test, one for each pressure value in the range of interest, should last until the complete saturation of the SIP and the attainment of a constant equilibrium pumping speed. The use of a quadrupole mass spectrometer (QMS) to follow the evolution of partial pressures during each test is of basic importance, in order to quantify the desorption from the SIP of each gas species and to distinguish the so-called active gases from non-getterable ones. Some examples of these analyses, with a particular focus on Ar and CH₄, will be shown in the following. In view of the combination pump these gases are particularly relevant because, as they cannot be pumped by NEG pumps, their sorption represents the main task of a SIP.

2. Experimental setup

SIP characterisations were performed on a dedicated experimental test-bench, whose layout is schematically described in

Fig. 1.

The system was made of a main vacuum vessel, with a volume of about 26 l, where a Pfeiffer Prisma Plus quadrupole mass spectrometer (QMS) for residual gas analyses and the SIP under test were installed. Following each pump installation, the system underwent a complete bake-out at 180 °C for 10 h, resulting in a base pressure typically in the 10⁻⁸ Pa range.

Gas leaked into the main volume through a known conductance C made by an orifice (0.025 l/s for Ar and 0.040 l/s for CH₄); the conductance value was estimated through geometry calculations for an orifice and confirmed by experimental pumpdown measurements. The entire system was pumped by a primary scroll pump (PS) connected in series to a turbomolecular pump (TMP).

As already mentioned, the adopted testing procedure was based on the known-conductance method. Two hot-cathode Bayard-Alpert gauges (Granville-Phillips 360/370 Stabil-Ion[®]), BAG1 and BAG2, were placed in proximity of the gas inlet and in the main volume near SIP and QMS, respectively. Gauges and QMS were calibrated against a certified gauge (BAG N₂ sensitivity: 0.37 A/Pa; QMS sensitivities: 1.35 × 10⁻⁴ A/Pa for N₂ and 1.59 × 10⁻⁴ A/Pa for CH₄). This layout allows performing tests both keeping constant P_{BAG2} (as prescribed by ASTM F798-97) or P_{BAG1} (i.e., setting a constant gas flow entering the main vessel).

According to this configuration, the quantity of gas Q pumped by the SIP (in Pa·l) is defined by:

$$Q = C \int (P_{BAG1} - P_{BAG2}) dt$$

and the corresponding pumping speed S (in l/s) is consequently given by:

$$S = C \left(\frac{P_{BAG1}}{P_{BAG2}} - 1 \right)$$

Furthermore, by substituting in this last equation P_{BAG2} with the partial pressure of the test gas measured by QMS, it is possible to calculate the effective pumping speed S_{QMS} of the SIP for this specific gas, leaving aside the influence of the others.

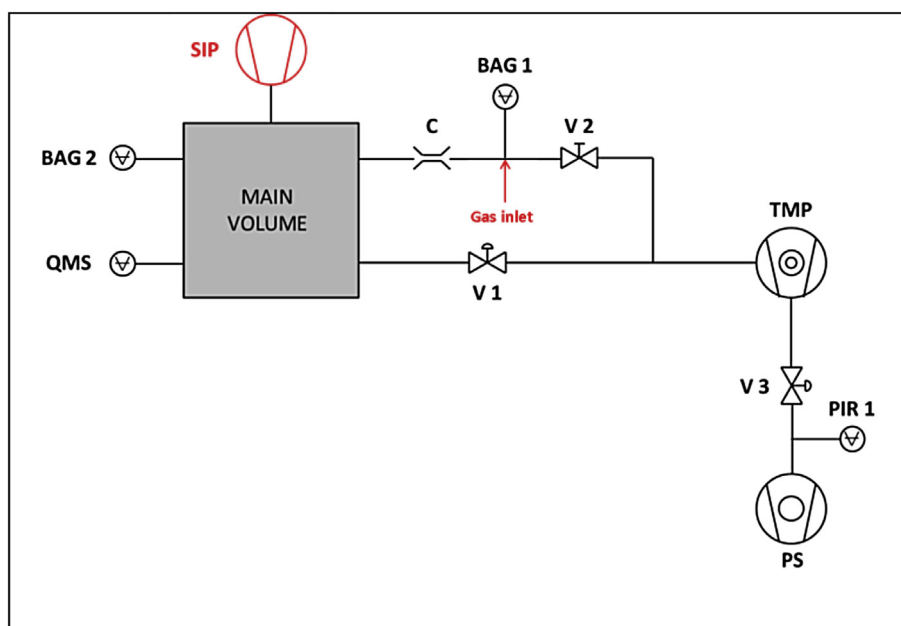


Fig. 1. Layout of the adopted experimental test-bench. Valve V1 connects the main volume to the scroll pump (PS) and TMP and it is closed during sorption tests. Valve V2 allows pumping at the gas inlet near BAG1.

Download English Version:

<https://daneshyari.com/en/article/1688226>

Download Persian Version:

<https://daneshyari.com/article/1688226>

[Daneshyari.com](https://daneshyari.com)