Publ. V Reunió Espanyola del Buit i les seves Aplicacions (Barcelona 1979)

NON-EVAPORABLE GETTERS AND NON-EVAPORABLE GETTER PUMPS AND THEIR USES

G.D. Clark
SAES GETTERS S.p.A. - 20151 MILANO - ITALY

ABSTRACT

The principal forms of non-evaporable getters i.e. alloy and high surface area types and their uses are discussed. The basic physico-chemical processes involved are illustrated to establish the non-evaporable gettering process.
Mention is also made of non-evaporable getter pumps and their applications including new large scale devices for fusion research etc.

1. INTRODUCTION

The purpose of a getter in any vacuum device is to act as a chemical pump, in order to remove gases evolved during the processing and life of the tube. Under many circumstances it is impossible to use a traditional evaporable barium getter and in these cases a non-evaporable getter (N.E.G.) is recommended. The reasons for a N.E.G.'s use vary but the major ones are:

a) low volume available
b) the absence of a suitable surface on which to deposit the barium film
c) the high vapour pressure of the barium film can cause inter-electrode leakage stray capicitance through migration and sublimation
d) small quantity of getter material available may be insufficient to maintain life

To overcome the above problems N.E. or Bulk getters are used, and especially in the following tubes: TWT's, Power Tubes, X-Ray Tubes, Vacuum Interrupters etc.

2. WHAT IS A N.E.G.?

These getters are based on alloys from metals of the IVA group and thorium or even the metals themselves (1,2). The reactions of the active gases with these metals under certain limits produce solid solutions for hydrogen and its isotopes; and chemical compounds with the other gases, such as O_2, CO, CO_2, N_2 etc. For hydrogen this solubility decreases with increasing temperature and reaches an equilibrium pressure which, in the solid solution region, obeys SIEVERTS LAW, where $\log P = X + \log q^2 - \frac{Y}{T}$

$P = H_2$ equilibrium pressure (torr)
$q = H_2$ quantity sorbed in cm^3 torr/mg
T = getter temperature (°K)
X-Y are constants of the getter material

However for the chemically sorbed gases such as CO the sorption speed and capacity increase with temperature, this being due to diffusion processes. Before being able to act as bulk getters these materials must be activated, in order to remove the thin passivating layer formed by reaction with the atmosphere on the surface of the getter. This is carried out by heating them to high temperature in vacuum to dissolve this layer into the bulk of the getter. Activation is normally carried out at 900°C for 30 secs; however, partial activaiton can be achieved at lower temperatures, provided the time is sufficiently long. This can ofter be achieved at the temperatures used in the tube processing (500-700°C).
The efficiency of a NEG is determined by its operation temperature and its real surface area. Thus, if low temperature operation is enforced by tube requirements then the surface area must be maximized, chosing a getter material with high diffusion characteristics. (3) In SAES GETTERS two ways are used to achieve this end.

a) Employment of special alloys, having superior diffusion properties
b) Considerable increase of the active surface area.

ALLOY GETTERS

Example of alloys in which greater diffusion propertieshave been achieved are the zirconium-titanium alloy (4) and the zirconium-aluminium alloys (1,5,6). The Zr-Ti alloys may be usefully used down to 350-400°C but can be used only as bulk of sheet metals due to their high plasticity. The Zr-Al alloys however can be easily reduced is powder and employed down to about 200°C and even room temperature for hydrogen. The Zr-Al alloy contains 16% Al and 84% Zr (by weight),known as the St 101 alloy, consists mainly of a mixture of two intermetallic compounds Zr_5Al_2 and Zr_3Al_2. Experiments have shown this composition to have the highest relative gettering rate. Fig. 1 shows the gettering propterties of a pressed powder pellet of this alloy at 400°C for CO compared with pure zirconium and Zr-Ti alloy. The Zr-Al (or St 101) alloy itself is produced in the form of ingots and then ground into a powder of less than 200μ. The powder is then supported by a metal holder in the form of a ring, pellet or strip.
St 101 getters have a large field of applications including: Magnetrons, Rare Gas Lasers, Scan Converters and in incandescent or fluorescent lamps where Ba getters cannot be used because of the dangers of the film reducing light output and reacting with their gas atmosphere

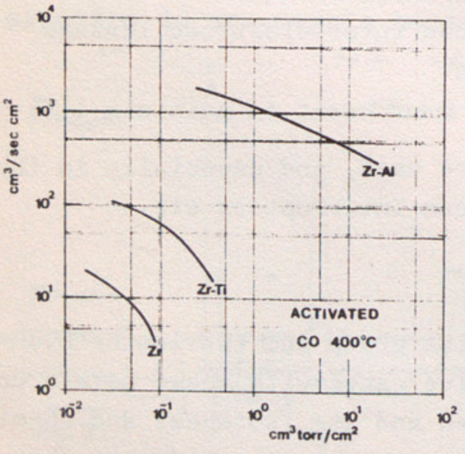

Fig. 1

HIGH SURFACE AREA GETTERS

If it is necessary to work at temperatures below 200°C e.g. room temperature, then a high porosity bulk getter is required. These getters are produced by using fine powders partially sintered to give a rigid body of highly porous material. Early type getters were a structure of Zr 50% + W 50%, the tungsten acting as anti-sintering medium (8.9). This getter though having good gettering properties suffers from loose particles. SAES GETTERS by proprietary processes produces a getter using Zr with C as the anti-sintering medium. This getter has an extremely high porosity 50% and surface area (10^4 cm^2/cm^3). The Zr-C getter, the St171 getter, can be used in a variety of forms, such as a traditional ring getter or as a compact body with an internal heater of insulated molybdenum which allows activation or heating whenever required. The characteristics at room temperature for this getter are shown in fig. 2.(10)

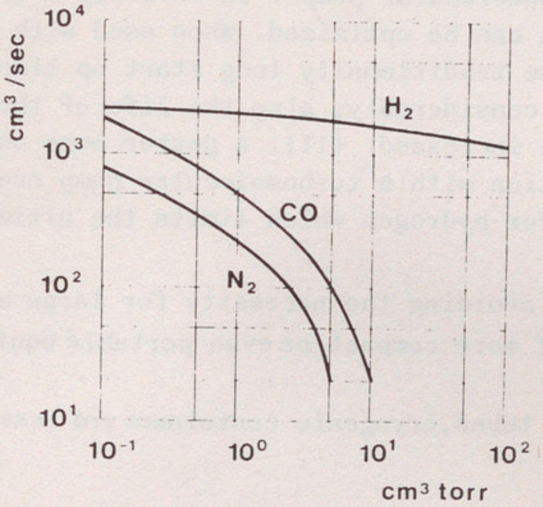

fig. 2

As for all N.E.G.'s St171 getters must be activated under vacuum to remove the protective surface layers. The ideal activation temperature being between 900 and 1000°C but lower temperatures are possible if longer times are used. At lower temperatures only partial activation will be achieved. In this case, only the gettering rates are reduced and not the overall capacity. One interesting aspect of the St171 getters and other N.E.G.'s when in the presence of hot filaments is their ability to pump hydrocarbons, albeit slowly. These gases are cracked on hot filaments in the tube and then the hydrogen is pumped away by the getter, and the remaining carbon deposits on the filament. Their good room temperature properties lend St171 getter to a number of applications in tubes where a long shelf life may be required or the tube operates at such temperatures e.g. X-Ray Tubes, Infra-Red Detector Dewars, Image Converters, Travelling Wave Tubes etc.

GETTER PUMPS

Previously the use of the St101 alloy by coating it onto a support strip was mentioned. This form of coated getter lead to the development of non-evaporable getter SORB-AC pumps. The coated strip can be easily slotted and then folded into a concertina form to give a very compact gettering body in the form of a cartridge, which can be used as the active element in a sophisticated and versatile form of high or ultra-high vacuum pump. The getter cartridge is placed over one or more heating elements for activation and for maintaining it at the operating temperature.
The pumps are mounted on flanges for direct connection to a vacuum system. They can be directly exposed to the internal volume of the vacuum system or when enclosed in a metallic housing they may be attached to the main system as a separate body. These pumps can be supplied in a range of sizes from 50 to 500 l/sec. This speed refers to the pumping speeds for CO; due to the selective nature of the pumps figures for other gases may be considerably different e.g. H_2 is much higher whereas N_2 is lower. The

The pumping characteristics of 500 l/sec pump for H_2 are shown in fig. 3. These characteristics are for an enclosed pump those of a nude pump being higher. Smaller versions of these pumps are also available. These 5-10 l/sec pumps are supplied with a glass envelope provided with a tubulation. This makes them suitable for mounting as appendage pumps.

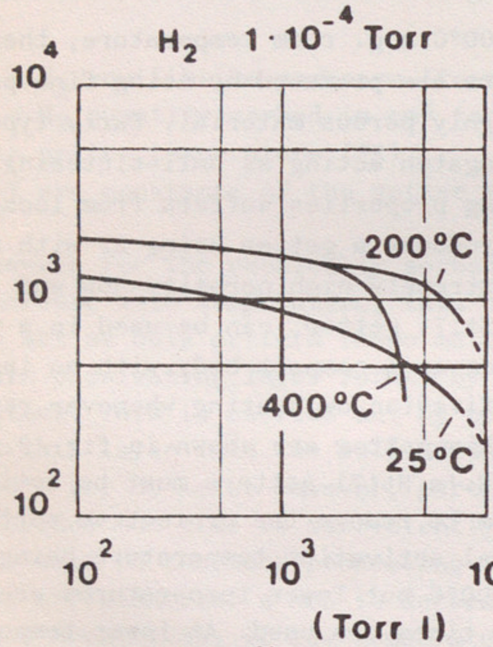

fig. 3

APPLICATIONS OF GETTER PUMPS

The cylindrical getter pumps can be used in several applications in traditional vacuum fields.

a) as process pumps during the production of vacuum tubes, i.e. in the vacuum line to improve production yield.
b) as auxilliary pumps, i.e. in combination with ion or turbomolecular pumps. In this way a vacuum system can be optimized. When used with an ion-pump the traditionally long start up time is reduced considerably, also the life of the ion-pump is increased. (11). A getter pump used in conjunction with a turbomolecular pump overcomes the problem of the latter's low efficiency for hydrogen which limits the ultimate vacuum attainable.
c) as a substitute for ion and sputter-ion pumps avoiding the necessity for large magnetic fields. This allows the construction of more compact or even portable equipment
d) as permanent pumps in large industrial vacuum tubes, cryogenic containers and lasers

WAFER PUMPS

Recently to cope with vacuum requirements of some advanced applications of vacuum technology a new type of volume getter pump has been developed. These use rectangular modules and are called Wafer Pumps. They are heated by direct passage of current, through the support-strip. The individual wafer modules, combined into large wafer panels, have extremely large pumping speeds ($1.5x10^4$ l/sec for H_2) making them ideal for use in large experimental vacuum systems such as particle accelerators and fusion machines. (12).

REFERENCES

1) P.della Porta et al 1961 trans.8th Nat.Vac.Symp.ed.L.E.Preuss (Perg.press Oxf'62)
2) A. Barosi and T.A. Giorgi Vacuum 23 (1973) 15
3) M. Nagasaka, E. Uyeda, and T. Yamashima Vacuum 23 (1973) 51
4) V.L. Stout and M.D. Gibbons J. Applied Physics 26 (1955) 1488
5) B. Kindl Supplemento al Nuovo Cimento 1.2 (1963) 646
6) A. Barosi: Residual Gases in Electron Tubes (Academic Press London 1972) p. 221
7) B. Kindl and E. Rabusin Supplemento al Nuovo Cimento 1.5 (1967) 36
8) N. Hansen Vakuum Technik 12 (1963) 163
9) N. Hansen Supplemento al Nuovo Cimento 1.2 (1963) 627
10) A. Barosi and T.A. Giorgi Vacuum Vol. 23 (1973) 15
11) P.della Porta and B. Ferrario Vuoto 1,2 (1968) 64
12) L. Rosai et al J. Vac.Sci.Tech. 15 (2) (1978) 746