I. INTRODUCTION

Plasma display technology is a very attractive method for fabricating large area HDTVs, making possible the production of panels with sizes greater than 40 in. The main advantages of this technology are the simple manufacturing process, the emissive wide viewing angle and the flicker-free images. Plasma displays can be divided into two main categories: direct current-plasma display panels (DC-PDPs) and alternating current-PDPs (AC-PDPs). From a materials and fabrication point of view, these two basic structures can be considered as quite similar. Two structures, in fact, employ the same substrate glass and gas mixtures and the same phosphors, barriers, black matrix and sealing materials. The most important difference concerning the material components is the presence of a MgO dielectric layer covering the electrodes of the AC-PDPs. A comparison between the internal geometric structures of the AC and DC panels is shown in Fig. 1. Plasma displays essentially use gas discharges to convert electrical energy into light: each pixel corresponds to a single discharge site and the light emitted by each pixel is electronically controlled by the video signal that represents the images. The filling gas in plasma displays must be chemically stable and have an intense radiation capability; binary gas mixtures of He, Ne or Xe are typically used at pressures between 300 and 500 mbar. The control of impurity level inside the discharge gas is an important issue for PDP technology development. In fact, although specific literature on gas contamination is not extensive, manufacturers experience shows that certain gas species, such as H$_2$ and H$_2$O, can increase the discharge voltage or contaminate the MgO layer (when present), thus affecting the display’s performance. Three main contamination sources can be identified inside a PDP: the residual gas after the exhausting process, the impurity content in the filling gas and the outgassing from internal components during display operation. To reduce these effects, an efficient exhausting process is necessary. However, the presence of barrier ribs significantly reduces the internal conductance of the displays, thus forcing manufacturers to pump the panels for a long period of time. In order to evaluate the residual gas pressure evolution during PDP exhausting, a specific mathematical model was developed. Different PDP configurations with and without a getter were considered. On the basis of this model, the pumpdown process appeared to be conductance limited: all the small channels and barrier ribs inside a PDP act as small conductances and place a lower limit on the final pressure attainable for a fixed outgassing rate. The limit is shown to be practically independent of both the applied pumping speed and the elapsed time before sealing. The results of the calculations show good agreement with experiments and allow evaluation of process time and residual contamination reduction through the use of a getter. According to these data, the role of the getter inside PDPs and its possible configuration are discussed. Nonevaporable getters (NEGs), mounted in a suitable arrangement inside the panels, appear able to act as in situ pumps during the production process (reducing the exhausting time) as well as gas purifiers during the life of the PDP (sorbing the outgassed species).

II. MATHEMATICAL MODEL

The aims of the development of a specific mathematical model representing the gas motion inside a PDP structure were:

1. to simulate the exhausting process of a display and to evaluate the impact of a getter on both the process duration and the final vacuum attainable;
2. to study the diffusion of the impurities inside the filling gas and estimate the getter’s ability to significantly reduce the pressure of the contaminants.

As it is known, the exhausting process is commonly carried out (starting from atmospheric pressure) using an external pumping system connected directly to the PDP through a small tube. For the purposes of this study, the PDP internal structure can be described as an array of small channels, with a rectangular section, all connected to a principal channel.

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**Getters and gettering in plasma display panels**

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In this article, starting from a calculation of the internal conductance inside AC and DC plasma display panels (PDPs), a simple theoretical model is used to estimate the pressure evolution inside a display during the exhausting process and the lifetime. All the values obtained are then compared to the results of specific measurements carried out on real PDPs. Based on these data, the role of a getter inside PDPs and possible getter configurations are discussed. According to the model proposed, the placement of nonevaporable getters (NEGs) inside the panel in a suitable arrangement is shown to improve the quality of the devices. A NEG can, in fact, act as an in situ pump during the production process (reducing the exhausting time) as well as a gas purifier during the life of the PDP (sorbing the outgassed species). © 1998 American Vacuum Society.

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A. Conductance calculation

During the exhausting process, the gas flow is driven by the pressure gradient induced by the external pumping system. Using the classical relation \( \frac{\partial \Delta p}{\partial t} = -\frac{\partial}{\partial x} \frac{\Delta p}{\Delta L} - \frac{q_p - \sum_{i=1}^{N_s} \Gamma (x, \tau) + \sum_{i=1}^{N_s} \Gamma (x, \tau)}{\Delta L} \), assuming a channel of constant section and the conductance being pressure independent in the molecular regime.

\[
\begin{align*}
A_p \frac{\partial P_p}{\partial t} & - c_p \frac{\partial^2 P_p}{\partial x_p^2} - q_p - F_s(x_p, \tau) + GP_p = 0, \\
A_s \frac{\partial P_s}{\partial t} & - c_s \frac{\partial^2 P_s}{\partial x_s^2} - q_s = 0, \quad 1 \leq i \leq N_s.
\end{align*}
\]

Subscript \( p \) indicates the primary channel, while subscript \( s,i \) indicates the \( i \)th of \( N_s \) secondary channels. \( A \) (cm\(^2\)) is the effective cross-sectional area of the channel. For AC-PDP, \( A_s \) is equal to the geometric area \( A_g \) of each secondary channel.

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\[
C = \frac{8 \omega Ka^2 b^2}{3 \pi (a + b)L},
\]
where \( K \) is a geometrical factor related to the \( a/b \) ratio and \( \omega = \frac{\pi u}{v_m} \), and \( u_m \) is the average gas velocity. The parameters of Eq. (1) are indicated in Fig. 2 as \( a_p, b_p, \) and \( L_p \) for primary channels and as \( a_s, b_s, \) \( L_s \) for secondary channels (actually \( b_p \) and \( b_s \) are the same in our model). In DC-PDPs, each single discharge cell is usually separated from the secondary channels by barrier ribs. Gas must flow through a gap a few microns wide between the barrier ribs and the covering glass plate. To estimate the conductance of such a structure, the Clausing equation\(^7\) for slits of rectangular section was used, with one side \( a_d \) (cm) much longer than the other side \( b_d \) (cm), and \( a_d \) much longer than the rib thickness \( l_d \) (cm) (not shown in Fig. 2). In the present case, the conductance \( C_d \) (cm\(^3\) s\(^{-1}\)) of each cell is:

\[
C_d = 3.668 \times 10^4 Ka_d b_d
\]
for air at 25 °C, where \( K \) is a tabulated factor function of the \( l_d/b_d \) ratio. \(^5\) In Table I the calculated specific conductances, which are given by the product of the total channel conductance \( C \) (cm\(^3\) s\(^{-1}\)) and the channel length \( L \) (cm), are given for the primary and secondary channels, together with the conductance of the gaps separating the discharge cells from the secondary channels. As can be seen, even if the discharge cells are connected to secondary channels via small gaps just a few microns high (as in the case of DC-PDPs), the effective conductance that reaches the external pumping system would be dominated by secondary channels only a few centimeters long. Hence, the conductance of discharge cells is not expected to influence the pumpdown process significantly and can be neglected. The main consequence of this result is, therefore, that the present model can be considered as valid for both AC- and DC-PDPs, without any significant difference.

B. Exhausting

To study the vacuum behavior in a PDP, a set of coupled linear monodimensional partial differential equations was numerically solved for the pressure \( P \) as a function of both the exhausting time \( t \) and the position \( x \) inside the channels. For symmetry reasons, only the lower part of a PDP (below line \( A-A' \) in Fig. 2) was considered. The system of equations was based on the standard vacuum flow equation, \(^8\) assuming a channel of constant section and the conductance being pressure independent in the molecular regime.

\[
A_p \frac{\partial P_p}{\partial t} - c_p \frac{\partial^2 P_p}{\partial x_p^2} - q_p - F_s(x_p, \tau) + GP_p = 0,
\]
\[
A_s \frac{\partial P_s}{\partial t} - c_s \frac{\partial^2 P_s}{\partial x_s^2} - q_s = 0, \quad 1 \leq i \leq N_s.
\]

with a larger section located along the panel perimeter, as shown in Fig. 2. In DC-PDPs, secondary channels are connected via small slits to the discharge cells, which also separate adjacent secondary channels. Gas must then flow from discharge cells into secondary channels and then into the primary channel before reaching the external pumping system. In AC-PDPs discharge cells are not present, and simple barrier ribs separate adjacent secondary channels. Use of a thin getter strip, with finite thickness, placed along the primary channel has also been considered.
section, while for DC-PDP $A_s = (A_g l_c + 2V_c)/l_c$, where $V_c$ is the discharge cell volume and $l_c$ is its length measured along the secondary channel. The contribution to the pressure increase inside the primary channel is given by the outgassing rate per unit of length $q$, which is assumed to be pressure and time independent during pump down, and by the linear density of the gas flow from secondary channels $F_s$ (cm$^2$ mbar s$^{-1}$); the opposite is given by the getter strip pumping speed per unit length $G$ (cm$^2$ s$^{-1}$). Finally, $c$ (cm$^4$ s$^{-1}$) is the channel specific conductance (see Table I). The boundary conditions must account for the presence of a pump at one end ($x_p = 0$) of the primary channel, with the other end ($x_p = L_p$) sealed. Mathematically they can be expressed for $t > 0$ as

$$
\frac{\partial P}{\partial x} (x_p = 0) = S_{\text{eff}}(P(x_p = 0) - P_u), \quad \frac{\partial P}{\partial x} (x_p = L_p) = 0,
$$

where $S_{\text{eff}}$ (cm$^3$ s$^{-1}$) is the effective pumping speed in the primary channel at $x_p = 0$ and $P_u$ (mbar) is the ultimate pressure of the pump. The effective pumping speed can be evaluated starting from the known speed of the pump $S_p$ (cm$^3$ s$^{-1}$)

**Table I.** Parameters used in numerical simulations.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary channel specific conductance</td>
<td>$c_p$</td>
<td>cm$^4$ s$^{-1}$</td>
<td>3.27</td>
</tr>
<tr>
<td>Primary channel specific conductance with getter (100 µm thick)</td>
<td>$c_p$</td>
<td>cm$^4$ s$^{-1}$</td>
<td>0.884</td>
</tr>
<tr>
<td>Secondary channel specific conductance</td>
<td>$c_s$</td>
<td>cm$^4$ s$^{-1}$</td>
<td>0.108</td>
</tr>
<tr>
<td>Discharge cell conductance</td>
<td>$C_d$</td>
<td>cm$^3$ s$^{-1}$</td>
<td>0.12</td>
</tr>
<tr>
<td>External pump to primary channel conductance</td>
<td>$C_{AB}$</td>
<td>cm$^3$ s$^{-1}$</td>
<td>0.192</td>
</tr>
<tr>
<td>Estimated linear density of outgassing rate from each secondary channel at room temperature</td>
<td>$q_s$</td>
<td>cm$^2$ mbar s$^{-1}$</td>
<td>$1.5 \times 10^{-6}$</td>
</tr>
<tr>
<td>External pump low pressure limit</td>
<td>$p_u$</td>
<td>mbar</td>
<td>$1 \times 10^{-5}$</td>
</tr>
<tr>
<td>Getter pumping speed</td>
<td>$G$</td>
<td>cm$^2$ sec$^{-1}$</td>
<td>2.1</td>
</tr>
<tr>
<td>Getter strip thickness</td>
<td>$h_G$</td>
<td>cm</td>
<td>0.01</td>
</tr>
</tbody>
</table>
at point A and combining it with the estimated conductance $C_{AB}$ of the vertical primary channel path AB (see Fig. 2):

$$S_{\text{eff}} = \frac{S_p C_{AB}}{S_p + C_{AB}}.$$  \hspace{1cm} (5)

In the present case, $C_{AB} = 2 c_p/ L_s$ is significantly lower than the speed $(10–100 \text{ s}^{-1})$ of a typical rotary and turbomolecular pump combination as shown in Table I. Since $S_p \gg C_{AB}$, from Eq. (5) we have $S_{\text{eff}} = C_{AB}$, hence the applied external pumping speed is significantly reduced. Furthermore, the effective conductance of the whole PDP is much less than $C_{AB}$ (see Table I) due to the presence of many small secondary channels, all of which are connected to the same primary channel. The whole pumpdown process is thus clearly conductance limited and depends, only for a very short transient time, on the speed and the capacity of the pumping system to which it is connected. Boundary conditions for secondary channels are given at the symmetry point in the PDP (along line AA’ on Fig. 2) and at the connection with the primary channel:

$$\frac{\partial P_{i,i}(x_s = L_s/2)}{\partial x_s} = 0, \quad P_{s,i}(x_s = 0) = P_p(x_p = i \cdot d_s),$$

$$1 \leq i \leq N_s,$$  \hspace{1cm} (6)

where parameter $d_s$ is shown in Fig. 2.

Mass conservation constraints applied at the secondary channel insertion points in the primary channel are used to determine the external gas flow for the primary channel, represented by term $F$ in Eq. (3), which corresponds to the fourth term on the right-hand side (RHS) of Eq. (7). Then a finite difference forward time centered space (FTCS) iteration scheme is applied to numerically integrate Eq. (3). The equations for the primary channel at nonboundary nodes $i(1 \leq i \leq N, \text{ i.e., } 0 < x_p < L_p)$ are then

$$P_{i,j}^{n+1} = P_{i,j}^n + r_s (P_{i,j}^n - 2 P_{i,j+1}^n + P_{i,j-1}^n) + q_s \Delta t / A_p$$

$$+ r_p (P_{i,j}^n - P_{i,j}^{n-1}) \Delta x_p A_s (1/A_p d_s) - G P_{i,0}^n \Delta t / A_p,$$  \hspace{1cm} (7)

where $r_p$ and $r_s$ are defined as follows:

$$r_p = \frac{\Delta t c_p}{\Delta x_p A_p}, \quad r_s = \frac{\Delta t c_s}{\Delta x_s A_s}.$$  \hspace{1cm} (8)

$\Delta x_p$ and $\Delta x_s$ are distances between adjacent nodes used for the finite-difference representation of the primary and secondary channels, respectively, whereas $\Delta t$ is the time step used in the FTCS iteration.

Indexing has been chosen such that $P_{i,j}$ identifies the pressure at node $i$ in the primary channel ($j = 0$) and at node $j(j > 0)$ in the $i$th group of secondary channels. Here we divide the $N_s$ secondary channels into $N$ groups of $\Delta x_p / d_s$ adjacent channels such that $N_s = N \Delta x_p / d_s$, assuming that the pressure does not change significantly within the same group. Thus each group of $\Delta x_p / d_s$ secondary channels contributes with a total flux of $D_{12}$.

$$\Delta x_p \frac{P^n_{i,j+1} - P^n_{i,j}}{d_s} \Delta x_s$$

$$\frac{P^n_{i,j} - P^n_{i,j-1}}{\Delta x_s}.$$  \hspace{1cm} (9)


to a portion of the primary channel with a length of $\Delta x_p$, giving rise to a rate of pressure increase in the primary channel

$$\frac{P^n_{i,0} - P^n_{i,-1}}{\Delta x_p} \Delta x_p \frac{P^n_{i,j+1} - P^n_{i,j}}{d_s} \Delta x_s$$

$$\frac{P^n_{i,j} - P^n_{i,j-1}}{\Delta x_s},$$

which gives, after some minor substitutions, the fourth term of the RHS of Eq. (7).

This procedure allows us to reduce the number of equations to be solved, and makes the numerical simulation much faster. Some cases were tested using different values of $\Delta x_p$, while keeping $N \gg 1$: no significant difference between the outcomes of the simulations was observed. At the pumping node ($i = 0$) the primary channel boundary conditions become

$$c_s \frac{D_{12}}{\Delta x_p} = C_{AB}(P^n_{i,0} - P_n),$$

while at the sealed node,

$$P^n_{N+1,0} = P^n_{N,0}.$$  \hspace{1cm} (11)

For secondary channels ($1 \leq i \leq N$), finite-difference equations at nonboundary nodes ($2 \leq j \leq M - 1$) are

$$P^n_{i,j+1} = P^n_{i,j} + r_s (P^n_{i,j+1} - 2 P^n_{i,j} + P^n_{i,j-1}) + q_s \Delta t / A_p,$$  \hspace{1cm} (12)

while at boundary nodes they are:

$$P^n_{i,1} = P^n_{i,1} + r_s (P^n_{i,2} - 2 P^n_{i,1} + P^n_{i,0}) + q_s \quad P^n_{i,M} = P^n_{i,M-1}.$$  \hspace{1cm} (13)

In order to satisfy the stability conditions for the FTCS iteration scheme, $\Delta t$ has been chosen such that $\Delta t < A_p \Delta x_p^2 / 2 c_p$ and $\Delta t < A_s \Delta x_s^2 / 2 c_s$. The mathematical model was coded in C (Borland Turbo C++ 3.0) and run on a microcomputer (AST MS 5133).

## C. Impurity diffusion

The use of the getter in PDP technology is aimed at not only at improving the production process, but also to act as an in situ pump during the display lifetime. To cope efficiently with the gas load during the PDP operation, a properly dimensioned getter should be able to sorb the gas released from the internal components, thus preventing an excessive increase of the concentration of performance-detrimental impurities. Since the filling gas pressure is typically in the range of 500 mbar, the intermolecular collisions dominate over the collisions of the molecules with the channel walls. For this reason the limiting factor to the gas flow motion is not the conductance but the diffusion of the impurities through the filling gas. The interdiffusion coefficient can be calculated using the following equation:

$$D_{12} = \frac{k T^{3/2}}{4 \pi} \left( \frac{M_1 + M_2}{M_1 M_2} \right)^{1/2} \frac{1}{P \sigma_{12}^2},$$  \hspace{1cm} (15)
where \( k \) is a numerical coefficient, \( M_i \) is the molecular weight, \( T \) is the absolute temperature (K), \( P \) is the total pressure (bar), \( \Omega_D \) is the collision integral and \( \sigma_{12} \) is a force constant related to the Lennard-Jones function potential. Calculated coefficients for different gas pairs often used in PDP technology are given in Table II. These values can be used to solve the classical diffusion equation for the partial pressure \( P \) of the contaminants:

\[
\frac{\partial P}{\partial t} - D_{12} \frac{\partial^2 P}{\partial x^2} = Q, \\
(16)
\]

where, for symmetry reasons, only one half of a single secondary channel (see Fig. 2) of length \( L_s \) (cm) and of uniform cross-sectional area \( A_s \) (cm\(^2\)) is considered. The channel has one end in front of a getter strip of total pumping speed \( S \) (cm\(^3\) s\(^{-1}\)) which should cope with an outgassing rate having a linear density \( Q \) (cm\(^3\) mbar s\(^{-1}\) cm\(^{-1}\)). The presence of a getter at one end (\( x = 0 \)) and the absence of a pressure gradient at the other end (\( x = L_s/2 \)) on the A-A’ symmetry line (Fig. 2) can be considered as boundary conditions:

\[
A_s D_{12} \frac{\partial P}{\partial x}(x = 0, t > 0) = PS, \quad \frac{\partial P}{\partial x}(x = L_s/2, t > 0) = 0. \\
(17)
\]

The typical transient time \( \tau \) to reach steady state in Eq. (3) is of the order of \( \tau = L_s^2/2D_{12} \) and the stationary solution is given by

\[
P(x) = \frac{L_s}{2 A_s S} \left( \frac{A_s}{S} + \frac{x^2}{D_{12} L_s} \right). \\
(18)
\]

In the present case the initial transient time is estimated to be extremely small (just a few minutes) compared to the expected lifetime of PDPs of up to 50 in. in size, and therefore Eq. (16) can be correctly solved at the steady state.

III. RESULTS AND DISCUSSION

As a first step, an actual 20 in. class PDP was subjected to an exhausting process at room temperature to experimentally study the pressure decrease rate inside the panel. The pressure evolution as a function of time was measured in the center of the display. This was accomplished using a SpiroTorr\textsuperscript{11} spinning rotor vacuum gauge tube sealed onto the PDP glass surface (previously pierced) by means of an epoxy resin (the position is shown in Fig. 2). At the same time, another pressure measurement was carried out using a Penning ionization gauge directly mounted onto the tube connecting the display to the pumping system (a 60 l/s turbomolecular pump combined with a rotary pump). The results of these measurements are reported in Fig. 3. As can be seen, the difference between the pressures measured in the two different positions is significant, reaching three orders of magnitude after 2 h of pumping. These data clearly indicate that efficient evacuation of the panel is quite difficult, primarily due to its small internal conductance: in a few minutes the pressure decrease became extremely slow, approaching, as expected, an asymptotic value only dependent on the PDP internal conductance and outgassing rate. The system of Eq. (3) was then solved using dimensional input values valid for a 20 in. class PDP in order to make a direct comparison to experimental results. Since outgassing data measured directly on operating PDPs are not presently available in the literature, data were experimentally obtained on display phosphors in SAES Getters R&D labs and used in the numerical simulation. As shown in Fig. 4, the slopes of the experimental and theoretical curves were initially quite different. This can be explained by the fact that the calculation assumed an initial pressure of 10 mbar inside the panel, while in the real case a pressure gradient was already present. However, the difference between the curves rapidly decreased, allowing them to reach very good agreement for periods longer than 10 min, thus confirming the validity of the mathematical model proposed. These results were compared with other simulations (not presented here) performed assuming secondary channels with smaller conductances. The comparisons show that the limiting factor for the overall conductance of a PDP with respect to an external pumping system is due to the primary channel even though its conductance is far greater than that of each secondary channel (see Table I). This is due to the fact that gas flowing from all secondary channels must pass through the same primary channel before reaching the external pump. While modifying the geometry of a PDP would contribute, at most, proportionally to the primary channel cross-sectional area to the

<table>
<thead>
<tr>
<th>Gas pairs</th>
<th>Interdiffusion coefficient (cm(^3) s(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>H(_2)-He</td>
<td>3.21</td>
</tr>
<tr>
<td>H(_2)-Ne</td>
<td>2.27</td>
</tr>
<tr>
<td>H(_2)-Ar</td>
<td>1.57</td>
</tr>
<tr>
<td>H(_2)-OHe</td>
<td>1.72</td>
</tr>
<tr>
<td>H(_2)-OHe</td>
<td>0.76</td>
</tr>
<tr>
<td>H(_2)-Ar</td>
<td>0.40</td>
</tr>
<tr>
<td>CO(_2)-He</td>
<td>1.21</td>
</tr>
<tr>
<td>CO(_2)-Ne</td>
<td>0.51</td>
</tr>
<tr>
<td>CO(_2)-Ar</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Fig. 3. Pressure evolution measured in different positions during the exhaust process in a 20 in. class PDP.
The introduction of a getter distributed along the primary channel acting as an in situ pump can easily improve the vacuum level by some orders of magnitude, as will be shown below.

The calculation was thus repeated taking into consideration the presence of a getter strip placed either inside the primary channel or inside a side chamber parallel to the channel itself. Even though the primary channel conductance is reduced by the getter strip (see Table I), a remarkable decrease of pressure resulted (seen in Fig. 4), indicating the ability of the getter to support the action of the external pumping system and to improve the exhausting process both in terms of the vacuum limit and the process time. In the real case, the getter activation (heating process necessary to clean the getter surface, thus making the getter itself able to sorb active gases) is not an instantaneous phenomenon and therefore a slower and more progressive pressure decrease must be expected in practice.

In the above simulation the panel was assumed to be at room temperature in order to allow a direct comparison with the experimental results. However, the exhaust process is typically made at higher temperatures (i.e., 350–400 °C), remarkably increasing the outgassing load. On the basis of the SAES Getters R&D labs, measurements performed on phosphors, a reasonable outgassing rate should be in the range of $10^{-4} \text{ cm}^3\text{ mbar cm}^{-2}\text{ s}^{-1}$. This value was then used to evaluate the total gas load coming from PDPs of different sizes during the production process. At the same time, the amount of getter that can be accommodated in the form of a thin strip along the primary channel was calculated for panel sizes ranging from 20 to 40 in. Knowing the getter pumping characteristics at high temperature, a comparison between the expected gas load and the total sorption capacity showed that no more than 50% of the active material is saturated during the process. Consequently, the getter should maintain a residual sorption capacity to permit it to act as an in situ pump during the life of the display, thus reducing the level of contaminants inside the filling gas. As discussed in Sec. II C, the interdiffusion coefficient of the contaminants in the filling gas is the limiting factor for their sorption by the getter. Assuming that the outgassing rate during PDP operation is in the range of $10^{-3} \text{ cm}^3\text{ mbar s}^{-1} \text{ cm}^{-2}$ (based on data concerning the gas release from phosphors), Eq. (17) was solved in the case of H$_2$O diffusion through Ne. The resulting pressure increase as a function of the secondary channel length is reported in Fig. 5, which shows that a local impurity level lower than 10 ppm can be maintained by the getter. According to available literature, this contamination level is well below the maximum limit required for proper PDP operation. The lack of outgassing data measured directly on displays during their operation could affect the reliability of this calculation. A deeper understanding of these phenomena is thus needed and further investigations will be carried out in the near future. Two items in particular will be studied: the outgassing characteristics of a real PDP and the impact of the pumping action of the MgO layer on the pressure evolution inside the displays.

Different types of NEG can be selected for application to PDP technology. A getter configuration that can cope with the speed and capacity pumping requirements as well as special geometrical constraints must be chosen. Getters having different characteristics in terms of sorption characteristics, activation temperature and shape are presently available: among the various types of getter solutions high porosity thick films (HPTF) strips appear to be the most suitable for this application. According to the previous discussion, a distributed getter solution, i.e., the use of a getter covering a certain surface area (as in the case of HPTFs) or positioned in a suitable configuration inside the panel (as in the case of pills), should be most favorable to significantly increase the pumping speed and reduce the process time. For cases in which electrical feedthroughs prevent mounting the getter strip directly along the primary channel, a HPTF getter mounted inside a small side chamber could be a solution. The compatibility of the production process with the getter characteristics is another fundamental issue. In fact, a low activation temperature getter can improve exhausting, but it cannot withstand process steps carried out in air at high temperatures. For this reason, the frit sealing of the two dis-
play glass plates must be performed under vacuum or in inert atmosphere. Knowledge of both the PDP characteristics and the production process is therefore necessary to select the suitable getter configuration for this application. Further development of different types of getter will be carried out in the future to best fit the producer’s specific needs.

IV. CONCLUSIONS

A specific mathematical model was developed to study gas motion inside a PDP. The results obtained show that the final vacuum attainable during the exhaust process is strongly dependent on the internal display conductance and outgassing rate, irrespective of the speed and capacity of the external pumping system. A distributed getter solution is shown to significantly reduce both the exhaust time and the vacuum limit. Moreover, the getter can act as an in situ pump, reducing the concentration of the impurities inside the filling gas during the PDP’s lifetime.