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# On some specifics in the selection of glass material for microchannel plates in space applications

*Yanko B. Dimitriev, Julika M. Simeonova**

*Higher Institute of Chemical Technology, Sofia*
**Space Research Institute, Bulgarian Academy of Sciences, Sofia*

The great interest in microchannel plates (MCP), particularly attributed to their space applications, is based on the successful combination of several substantial parameters determining their large functional capacity. However, the latter strongly depend on many factors, such as selection and production of the glass material and its further processing, on the technology of microchannel structure, on the operation mode, and the manner of storing MCP, etc.

The purpose of this paper is to discuss some peculiarities of the glass material which may affect the operational parameters of the MCP, especially during their continuous exposure in space.

Laboratory tests affirm that, regardless of the preliminary treatment of the plates in vacuum medium in order to degas them, they continue to release gases [1]. The curves revealing the kinetics of residual gas release in some spectral lines for plates performing in high vacuum also confirm this [2]. It should be expected that gas release would take place in space too and would affect the operational parameters. This assumption is corroborated by the established effect of gas admixture in glass on the coefficient of amplification of secondary channel multipliers, together with the contribution of glass-dissolved water [3].

Glass is widely applied material in electrovacuum production. Therefore, the attention to gas composition and diffusion in glass might be easily understood. It is known that already in the process of glass synthesis there are residual amounts of $H_2O$, $CO_2$, $O_2$, $H_2$, $N_2(CO)$, etc. [4]. Besides, the final product absorbs gases on its surface, which may diffuse. During the glass heating up to 300° C in vacuum, the absorbed gases and water are released from its surface and subsurface layers, while those dissolved in the bulk material evolve at higher temperatures [4-6]. The glass structure and the initial content of OH-groups in it affect water diffusion [7, 8]. The glass state — quenched

or tempered — is also of particular importance [5]. Water incorporation and release in glass can be described with the following reaction:

$$H_2O+(\equiv Si—O—Si\equiv)=2(\equiv Si—OH)$$

Predominant is the opinion that at low content of glass-dissolved water (below 0,1%) it is completely manifested by OH-groups [9-11].

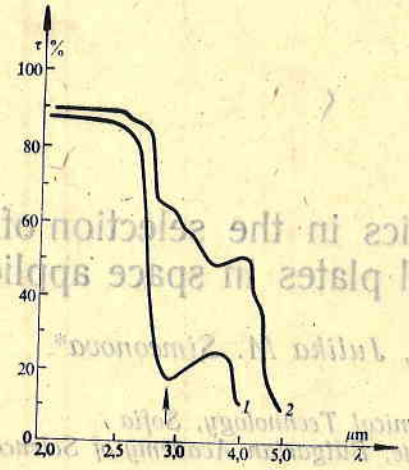


Fig. 1. Dependence of the transmission coefficient on the wave length for two glass compositions

The transmission (absorption) spectra of light in the near infrared region allow to determine the presence of OH-groups and the extent of their relationship with the other structural units in glass. The absorption peak at 2,8 μm (3550 $cm^{-1}$) could be assigned to the fundamental stretching vibrations of OH [12]. Consequently, these spectra could be used for testing water composition in glass and for selecting glass composition for MCP designed for long exposure in high vacuum, i. e. for space applications.

As an example we shall examine the transmission spectrum of two different lead-silicate glass compositions used in MCP technology. The first material *(1)* contains $SiO_2$, PbO, $B_2O_3$, and $Bi_2O_3$ and $Al_2O_3$. Its spectrum is shown in Fig. 1 and is specified with an intense absorption peak at 2,7-2,9 μm, typical for OH-groups. The latter do not contribute to the formation of hydrogen bonds. The second material *(2)* contains, besides the mentioned components, $Na_2O$ and $K_2O$. Its spectrum is much more complex in terms of the examined region. Due to the weaker absorption within the range of 2,7-4 μm, we may assume that the water content is smaller. The complex nature of the spectrum may be assigned to the existence of modifying cations generating non-bridge oxygen bonds within the glass network. This leads to the formation of stable hydrogen bonds between Si-OH and the non-bridge oxygen ions. As a result, the absorption maximum (the maximum in the transmission spectrum) is displaced towards longer wave lengths.

It may be concluded, therefore, that with the introduction of additional modifying oxides in the glass material, it is possible to control the total amount of water and the extent of its bondage in the glass. This is of prime im-

portance for its further behaviour along the MCP exploration. The proper selection of the glass material should ensure the stable amplification of microchannel plates during their continuous performance in space vacuum.

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## О некоторых особенностях при выборе стекла для микроканальных пластин, работающих в космосе


*Я. Б. Димитриев, Ю. М. Симеонова*



(Резюме)

Некоторыми авторами было установлено влияние растворенной в стекле воды на коэффициент усиления каналовых электронных умножителей. В связи с этим проведено исследование спектра пропускания света через свинцово-силикатное стекло из двух составов в области 2—5 μm, позволяющее получить информацию о присутствии OH-групп и о их связи с остальными элементами структуры. В спектре стекла, содержащего $SiO_2$, PbO, $B_2O_3$, $Al_2O_3$ и $Bi_2O_3$, обнаружен интенсивный адсорбционный пик (2,7—2,9 μm), который характерен для OH-групп, не образующих водородных связей. Спектр другого стекла, содержащего еще $Na_2O$ и $K_2O$, сложнее из-за присутствия модифицирующих катионов и его поглощение более слабое. Следовательно внесением дополнительных модифицирующих окислов в стекло можно регулировать общее количество воды и степень ее связанности, что существенно при выборе стекла для микроканальных пластин со стабильным усилением при продолжительной работе в условиях космического вакуума.