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VOLUME INTERCONNECTION RATES IN TRACK ETCHED MEMBRANES WITH VARIOUS ANGULAR DISTRIBUTIONS

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1. INTRODUCTION

As well known the angle distribution (AD) of ion tracks in polymeric foils produced by the fission fragments of uranium atoms in nuclear reactors has the three dimensional one. In the case of track membranes produced on the high energy heavy ion accelerators is very difficult to obtain the same AD as in nuclear reactors. In parallel geometry of pores, when all trajectories of incident ions are parallel, if two or more pores overlapped on the one surface of the membrane than these holes will be overlapped on the opposite surface too. The AD allows to decrease of the multiple pore overlapping along of the length of pores, i.e. two or more overlapped pores on one surface can have the various angles to the normal surface direction and as a result the overlapping is absent on the another surface. So, this AD is a way in the production of the sterilizing membranes for the biomedical purposes. And secondly the AD gives possibilities to obtain the overlapping of pores in the volume of membrane for the increasing of water and gas flow rates in the processes of filtration and as a consequence for the increasing of life time of the membrane.

The goal of this article is the estimation of the probability of volume interconnection rates (PVIR) of pores with various angle distributions in track etched membranes (TM).

2. METHOD OF CALCULATIONS OF PROBABILITY OF VOLUME INTERCONNECTION RATES

The relative number of overlapped pores can be determined using of the simple expression:

$$W_{over} = N_{over}/N, \quad (1)$$

here N_{over} and N are the numbers of overlapped pores in the volume of material and the tracks on a area S consequently. Here the value $N = n*S$ and n is the track density. The value W_{over} is strongly depends on the angular distribution of tracks. To estimate of the W_{over} value in the case of parallel geometry of tracks is very easy. As well known the probability of double pore overlapping has the following form [1,2]:

$$W^1 = [1 - \exp(-4*P)], \quad (2)$$

where $P = \pi*D^2*n/4$ is the porosity of track membrane, D is the diameter of the pore.

In the case of the TM production on high energy heavy ion accelerators [3] can be used the following multi-plane angular distributions:

I_1 - the double angular distribution along the width of the membrane $\alpha = \pm\alpha_{max}$; at $\beta_{max} = 0^0$;

I_2 - the homogeneous distribution of angle $\beta \subset [-\beta_{max}, +\beta_{max}]$ along the membrane length at $\alpha_{max} = 0^0$;

I_3 -the double angular distribution along the width of the membrane $\alpha= \pm\alpha_{max}$ and homogeneous angle distribution $\beta \subset [-\beta_{max},+\beta_{max}]$ along the length of the track membrane (the composition of cases I_1 and I_2).

And for TM producing on nuclear reactors or with special technique on heavy ion accelerators one can write the following angular distribution:

I_4 - the three dimensional angle distribution $\alpha \subset [-\alpha_{max}, +\alpha_{max}]$ and $\beta \subset [-\beta_{max}, +\beta_{max}]$, where angles α_{max} and β_{max} may be equal one each other, i.e. $\alpha_{max} = \beta_{max}$. As very easy to see this case corresponds to double composition of case I_3.

To solve the problem formulated above is very difficult using of the theory of the probability, because with the increasing of the porosity (P) the relative number of overlapped pores (W_{over}) much more than the unit in many cases ($W_{over} > 1$), i.e. the probability of that process is equal to unit practically from the small angles (α and β, see cases of I_1 - I_4) to big ones.

From our point of view for the calculations of relative number of overlapped pores (W_{over}) the simplest way is to use of the a Monte Carlo simulation. It is well known that this method is used when practically impossible to solve task analytically. Also, this method allows to obtain the probabilities of multi pore overlapping in the volume of membrane (W_m, where m = 1,...,10 and so on).

There is only one limitation connected with the necessivity to raffle off a significant quantity of events (the number of tracks N on a square $S = L * L$ should satisfy the condition $N^{1/2}/N << 1$, here S is a square with the length of side L).

The scheme of calculations was following. The position of each admission pore (as example i pore) on one surface of membrane is described by twice coordinates (X_i, Y_i). The coordinates may be represented in the form in Monte Carlo method:

$$X_i = L*\Theta_i \ , \ \ Y_i = L*\Omega_i \ , \ \ i = 1, N, \qquad (3)$$

where the Θ_i and Ω_I are the random numbers in the interval from 0 to 1 (i.e. Θ_i and $\Omega_i \subset [0,1]$), $N = S * n$ is the number of accidental events in area S. The position of outlet pore in common case can be written as:

$$X_i^{'} = X_i + H*tg(\alpha_{max}*K_{1i}),$$
$$Y_i^{'} = Y_i + H*tg(\beta_{max}*K_{2i}), \ i = 1, N, \qquad (4)$$

here H is the thickness of the membrane, parameters K_{1i} and K_{2i} may be presented in the following forms:

$$K_{1i} = +1,\ i = 1, N/2,\ \ K_{1i} = -1,\ i = N/2, N$$
$$\text{and } K_{2i} = 0 \qquad \text{(the case } I_1) \qquad (5^1)$$

$$K_{1i} = 0,\ \ K_{2i} = 1 - 2*\varsigma_i,$$
$$\varsigma_i \subset [0,1],\ i = 1, N \qquad \text{(the case } I_2) \qquad (5^2)$$

$$K_{1i} = +1,\ \ i = 1, N/2,$$
$$K_{1i} = -1,\ i = N/2, N,$$
$$K_{2i} = 1 - 2*\varsigma_i,\ \ \varsigma_i \subset [0,1],$$
$$i = 1, N \qquad \text{(the case } I_3) \qquad (5^3)$$

$$K_{1i} = 1 - 2*\varsigma_i,\ \ \varsigma_i \subset [0,1],\ \ i\ 1, N$$
$$K_{2i} = 1 - 2*\Lambda_I,\ \ \Lambda_i \subset [0,1],$$
$$i = 1, N \qquad \text{(the case } I_4) \qquad (5^4)$$

Where Λ_i and ς_i are the random numbers.

The number of overlapped pores on both surfaces may be found from the conditions:

$$\Delta^2 = (X_i - X_j)^2 + (Y_i - Y_j)^2 < D^2$$
$$\Delta'^2 = (X'_i - X'_j)^2 + (Y'_i - Y'_j)^2 < D^2,$$
$$i, j = 1, N. \qquad (6)$$

For the calculations of the volume pore overlapping we used simple method. The thickness of membrane was divided on the layers with the thickness of ΔH (for the correct calculation ΔH has to satisfy the condition: $\Delta H < D$). The numbers of such layers will be $M = H/\Delta H$. In each layer the number of overlapped pores was calculated using the condition:

$$\Delta^2 = [X_i(H_k) - X_j(H_k)]^2 + [Y_i(H_k) - Y_j(H_k)]^2 < D^2,$$
$$i, j = 1, N, \qquad (7)$$

where $(X_i(H_k), Y_i(H_k))$ and $(X_j(H_k), Y_j(H_k))$ are the coordinates of two pores in the layer with the number k, and the depth of this layer is $H_k = \Delta H*k$, where $k = 1, M$.

If the pores were overlapped in previous layer (k-1) and saved overlapping in the next layer (k) such event should be taken out. So the total number of overlapped pores was calculated. In the same time the calculations of the total (Σ_{tot}) and relative ($\delta = \Sigma_{tot}/S$) squares of overlapping in the volume of membrane has been carried out. This parameter is very important because it determines the gas or water flow rate throughout the membrane and life time (the time of the filtration process bring to a stop) of the membrane in the processes of filtration.

The value of overlapped area of two pores on the distance Δ (see equations (6) and (7)) should be found from the expression:

$$S_2 = 2*S_0 - \{[\arccos(\Delta/D)*D^2 - D*\Delta*[1 - (\Delta/D)^2]^{1/2}\}/2 . \quad (8)$$

Here $S_0 = \pi*D^2/4$ is the area of the one isolated pore. Thus with the calculation of the number of overlapped pores in the layer k very easy to estimate of the area of the overlapping of i and j pores - $S_2(k,i,j)$. Then the comparison of $S_2(k',i,j)$ has been carried out in various layers k' for the finding the maximum value. The total area of overlapping (Σ_{tot}) is the sum of the maximum values of the double overlapped pore squares. As very easy to see in the case of multiple overlapped pores (if pore with the number i overlapped with the j_1, j_2, j_3 and so on pores) the account of a few times of the same overlapped area is possible (this event will be if the following pores are overlapped (i,j_1), (i,j_2), (i,j_3) and (j_1,j_2), (j_2,j_3) and so on overlapped too). For the correct account of the overlapped areas the total quantity of pores which overlapped more then two times (N_{cor}) has been carried out. Then the correcting value of area was determined from the expression:

$$\Sigma_{cor} = S_0*N_{cor}*\varepsilon , \quad (9)$$

here the parameter ε is the correcting coefficient and one can estimate it from the modeling calculations. In this paper the value of this coefficient was in limits 0.7 - 0.8. Thus the total and relative areas of overlapping of pores in the volume of membrane have the expressions, consequently:

$$\Sigma_{final} = \Sigma_{tot} - \Sigma_{cor} , \ \delta = \Sigma_{final}/S . \quad (10)$$

Also the probabilities of multiple pore overlapping in the volume of membrane with the multiplicity's up to 10 were calculated in this model. For this purposes the quantities of multi overlapped pores (N_m) have been calculated and the probabilities have been accounted using the form:

$$W_m = N_m/N, \ m = 1, ..., 10 . \quad (11)$$

The value of N has been taken from the condition described above ($N^{1/2}/N << 1$) and another one, connected with the increasing of the square of outlet pore surface (S_{new}) in comparison with the area S. So this condition has a form:

$$(S - S_{new})/S << 1 \qquad (12)$$

S_{new} can be written as

$$S_{new} = [L + 2*H*tg(\alpha_{max})]*[L + 2*H*tg(\beta_{max})] \; . \qquad (13)$$

After a simple transformation one can write:

$$N >> 16*H^2*P*[tg(\alpha_{max}) + tg(\beta_{max})]^2/(\pi *D^2) \; . \qquad (14)$$

In the next part of this article the results of numerical calculations will be carried out.

3. NUMERICAL RESULTS AND DISCUSSIONS

In our calculations the following parameters of TM were used:

- the membrane thickness were h = 5, 10 and 20 μm;
- the track density was $n=10^9$ track/cm^2;
- the angles $\alpha_{max} = \beta_{max} = 30^0$;
- the diameter of pores were D = 0.05, 0.075, 0,10 and 0.15 μm and corresponded to following porosity's of membran P = 1.96, 4.42, 7.85 and 17.67%.

3.1. THE DOUBLE ANGULAR DISTRIBUTION ALONG THE WIDTH OF THE MEMBRANE {$\alpha = \pm\alpha_{max}$ and $\beta_{max} = 0^0$ (Variant I_1)}

In figure 1 the distributions of relative numbers of overlapping vs. angles α_{max} are presented. Curves 1 - 4 correspond to the diameters of pores 0.05, 0.075, 0.10 and 0.15 μm. The parameter ΔH in these calculations was 0.1 μm and for the estimations of accuracy of results in the case of small diameters (D = 0.05 and 0.075 μm) ΔH was varied from 0.05 to 0.75 μm. There was no any big differences. As one can see all dependencies can be described by simple expression:

$$W_{over}(\alpha_{max})=0.13*2*\pi*D*h*n*\alpha_{max}+0.5*W^1, \qquad (15)$$

where angle α_{max} should be measured in radians.

In figure 2 the dependencies of the relative volume area overlapping of pores ($\Delta S/S$ %) vs. the angle α_{max} are presented. Curves 1 - 3 correspond to the pore diameters D = 0.075, 0.10 and 0.15 μm respectively. Here the dependencies $\Delta S/S(\alpha_{max})$ are not a linear as in the case of W_{over} and grow more quickly with the increasing of pore diameters (for the diameter D =0.15 μm at angle $\alpha_{max} = 30^0$ the value $\Delta S/S$ = 75 %).

In figures 3 and 4 the probabilities of multi overlapping of holes (W_m, m=1,...,10) vs. the angle α_{max} for the diameters D =0.10 and 0.15 μm are presented respectively. As one can see from the figures 3, 4 the maximum of multi pores overlapping in the case of pore diameter D = 0.15 μm has a shift of about 10^0 in comparison of the case of pore diameter D= 0.10 μm. And the decreasing of W_m at $m < 10$ connected with the grow of the W_m where $m > 10$.

3.2. THE HOMOGENEOUS DISTRIBUTION OF ANGLE $\beta \subset [-\beta_{max}, +\beta_{max}]$ ALONG THE MEMBRANE LENGTH AT $\alpha_{max} = 0^0$ (Variant I_2)

In figure 5 one can see the distribution of $W_{over}(\beta_{max})$ vs. the angle β_{max} for various pore diameters (D = 0.05, 0.075, 0.10 and 0.15 μm, respectively). From this figure it is clear that these dependencies of values $W_{over}(\beta_{max})$ have linear character vs. angles β_{max}. The simple expression for the estimations of $W_{over}(\beta_{max})$ was obtained, as in the variant 1:

$$W_{over}(\beta_{max})= 0,1*2*\pi*D*h*n*\beta_{max}+0.5*W^1, \qquad (16)$$

where angle β_{max} should be measured in radians.

In figure 6 the dependencies of the relative volume area overlapping of pores ($\Delta S/S$ %) vs. the angle β_{max} are presented. Curves 1 - 4 correspond to the pore diameters D = 0.05, 0.075, 0.10 and 0.15 μm respectively. As very easy to see here the all dependencies have linear character. The comparison of figures 1 and 5 and figures 2 and 6 allow to conclude that in variant 1 the relative number of overlapped hole is W_{over} = 6.75 much more then in variant 2, where W_{over} = 5. However the relative area of volume overlapping in variant 1 is of about $\Delta S/S \cong 70$ % and in variant 2 is $\Delta S/S$ = 145% (all these values are taken for the parameters: D = 0.15 μm and angles α_{max} and $\beta_{max} = 30^0$).

For the understanding of this calculated facts in figure 7 the probabilities of multi overlapping of holes (W_m, m=1,...,10) vs. the angles β_{max} are shown. The parameters were the following: D = 0.15 μm, n = 10^9 cm^{-2}, h = 10 μm. As one can see the probabilities of multiple pore overlapping $W_m(\beta_{max})$ much more than the same ones $W_m(\alpha_{max})$ for the angles more than 15^0. As it will be shown below the same reason should be in the case of three dimensional angle distribution too.

If we will correct the values $\Delta S/S$ % on the angles α_{max} and $<\beta_{max}>$ with the use of expressions (it necessary to do because the area of two overlapped pores is the ellipse with one axis is equal to $D' = D/\cos(\alpha_{max})$ and another axis is equal $D'' = D/\cos(<\beta_{max}>)$, where $<\beta_{max}>$ is the medium angle of distribution on β_{max}):

$$(\Delta S/S\ \%)_{correct} = (\Delta S/S\ \%)/[\cos(\alpha_{max})*\cos(<\beta_{max}>)]\ . \qquad (17)$$

If one use this expression for the estimation of $(\Delta S/S\ \%)_{correct}$ for angles 30^0 for the variants 1 and 2 the big differences will be kept too.

3.3. THE DOUBLE ANGULAR DISTRIBUTION ALONG THE WIDTH OF THE MEMBRANE $\{\alpha = \pm\alpha_{max}\}$ AND HOMOGENEOUS ANGLE DISTRIBUTION $\{\beta \subset [-\beta_{max}, +\beta_{max}]\}$ ALONG THE LENGTH OF THE TRACK MEMBRANE (Variant I_3)

In figure 8 the dependencies of $W_{over}(\beta_{max})$ vs. the angle β_{max} . The curves 1 -3 correspond to the $\alpha_{max} = 5^0$, $\alpha_{max} = 3^0$ and $\alpha_{max} = 0^0$ respectively. Curve 4 is the dependence of $W_{over}(\alpha_{max})$ vs. the angle α_{max} at the value of angle $\beta_{max} = 0^0$. The parameters here are the following: $n = 10^9\ cm^{-2}$, $h = 10\ \mu m$ and the pore diameter is $D = 0.15\ \mu m$.

As one can see with the increasing of angle α_{max} the relative number of overlapped pores W_{over} grow in comparison with the variant 2 practically additively like as

$$W_{over}(\alpha_{max}, \beta_{max}) = W_{over}(\beta_{max}) + W_{over}(\alpha_{max})\ . \qquad (18)$$

Its very good seen from the behavior of curves 3 and 4 at $\beta_{max} = \alpha_{max} = 0^0$, where the value $W_{over} = W^1$ (see equation (2) at the porosity P = 17.67 %).

So, we concluded that the use of the variant 3 of angle distribution for the big values of angle β_{max} and small value of angle α_{max} is not very effective in comparison of variant 2.

This conclusion can be supported by the results which are presented on the figures 9 and 10 where the probabilities of multi overlapping of holes (W_m, m=1,...,10) vs. the angles β_{max} are shown (for $D = 0.15\ \mu m$ - figure 9 and $D = 0.10\ \mu m$ - figure 10). The parameters of calculations were the following: $n = 10^9$ cm^{-2}, $h = 10$ μm and $\alpha_{max} = 5^0$. From the comparison of figures 10 and 7 one can see that for big angles $\beta_{max} > 10^0$ there are practically no differences, only for the angles $\beta_{max} < 10^0$ the situation with the multi overlapping probabilities of pores much better in variant 3, because for these angles W_m, m = 3,4,5,6,7 much more and W_2 is a small than for variant 2.

3.4. THE THREE DIMENSIONAL ANGLE DISTRIBUTION {$\alpha \subset [\alpha_{max}, +\alpha_{max}]$ and $\beta \subset [-\beta_{max}, +\beta_{max}]$} ALONG THE LENGTH AND WIDTH OF THE TRACK MEMBRANE (Variant I_4)

We observed here the variant 4 with the condition $\beta_{max} = \alpha_{max} = 30^0$. In figure 11 the dependencies of $W_{over}(\beta_{max},\alpha_{max})$ vs. the angle $\beta_{max} = \alpha_{max}$ are presented. The curves 1 - 2 correspond to the pore diameters D= 0.10 and 0.15 μm respectively. The parameters here are the following: $n = 10^9$ cm^{-2}, $h = 10$ μm. As one can see the grow of $W_{over}(\beta_{max},\alpha_{max})$ more strong in comparison with the other variants of angle distributions.

In figure 12 the dependencies of the relative volume area of overlapping of pores ($\Delta S/S$ %) vs. the angle $\beta_{max} = \alpha_{max}$ are presented. Curves 1 - 2 correspond to the pore diameters D = 0.10 and 0.15 μm respectively. As one can see the grow of $W_{over}(\beta_{max},\alpha_{max})$ and $\Delta S/S$ more strong in comparison with the other variants of angle distributions

In figure 13 the probabilities of multi overlapping of holes (W_m, m=1,...,10) vs. the angles α_{max} and β_{max} are presented. Here the calculations were carried out for the diameter D= 0.15 μm, and other parameters were the same as in figure 11. As it possible to see from this figure 13 the maximums of W_m for m = 10, 9, 8 and 7 take a place at angles α_{max} and β_{max} less then 13^0. So this variant of multiple overlapping better in comparison of other variants.

4. CONCLUSION

In the table 1 the values of $W_{over}(\alpha_{max}, \beta_{max})$, $W_{over}(\alpha_{max}, \beta_{max}=0^0)$ and $\Delta S/S$ at the maximum values of angles are presented for variants 1 - 4 of angle distributions.

Table 1.

Angles	$\alpha_{max}=30^0$ $\beta_{max}=0^0$ variant 1	$\alpha_{max}=0^0$ $\beta_{max}=30^0$ variant 2	$\alpha_{max}=3^0$ $\beta_{max}=30^0$ variant 3	$\alpha_{max}=5^0$ $\beta_{max}=30^0$ variant 3	$\alpha_{max}=30^0$ $\beta_{max}=30^0$ variant 4
$W_{over}(\alpha_{max},\beta_{max})$	6.75	5.17	5.37	5.58	7.5
$W_{over}(\alpha_{max},\beta_{max}=0^0)$	0.34	0.34	1.11	1.62	0.34
$\Delta S/S$, %	68	148	163	171	230

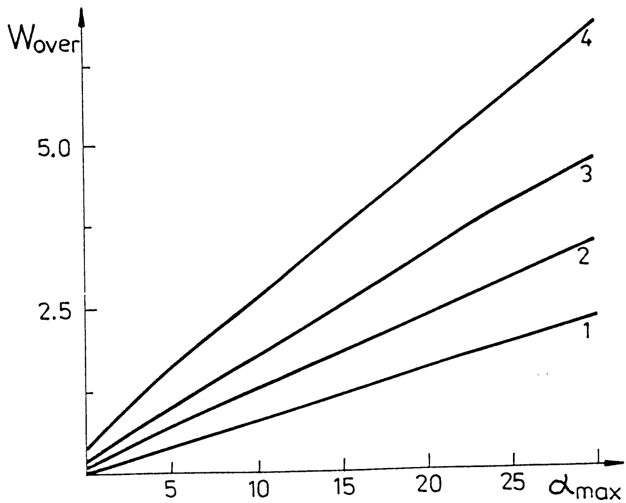

Figure 1. The dependencies of $W_{over}(\alpha_{max})$ vs. the angle α_{max}. The parameters are following: n= 10^9 cm^{-2}, h = 10 μm. The curves 1 - 4 correspond to pore diameters D = 0.05, 0.75, 0.10 and 0.15 μm, respectively (variant 1).

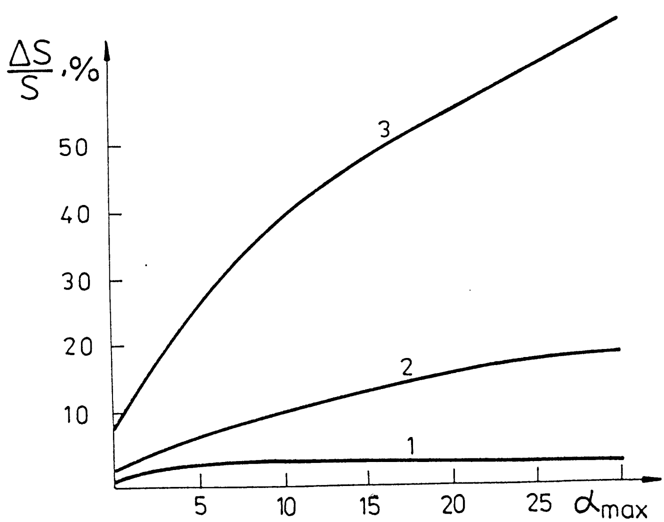

Figure 2. The dependencies of the relative volume area overlapping of pores (ΔS/S %) vs. the angle α_{max} are presented. Curves 1 - 3 correspond to the pore diameters D = 0.075, 0.10 and 0.15 μm respectively (variant 1).

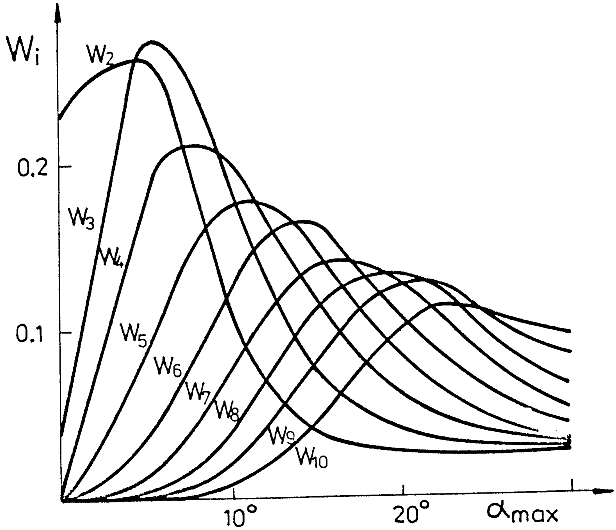

Figure 3. The probabilities of multi overlapping of holes (W_m, m=1,...,10) vs. the angle α_{max} for the diameter of pores D =0.10 μm are presented (variant 1).

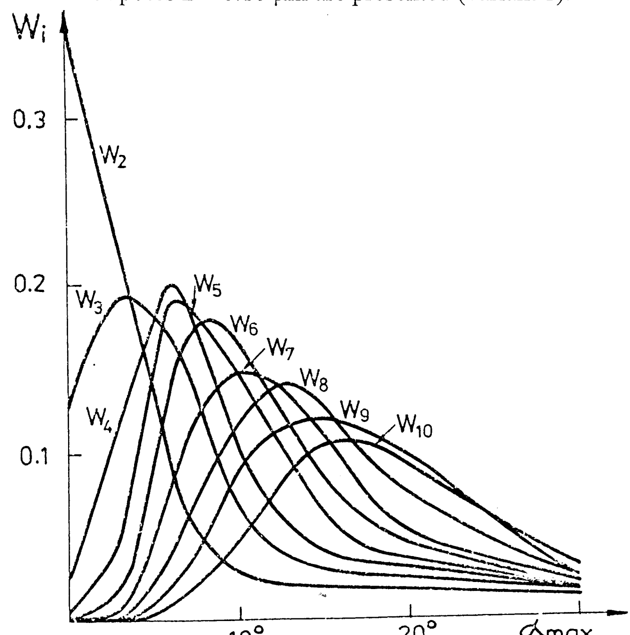

Figure 4. The probabilities of multi overlapping of holes (W_m, m=1,...,10) vs. the angle α_{max} for the diameter of pores D = 0.15 μm are presented (variant 1).

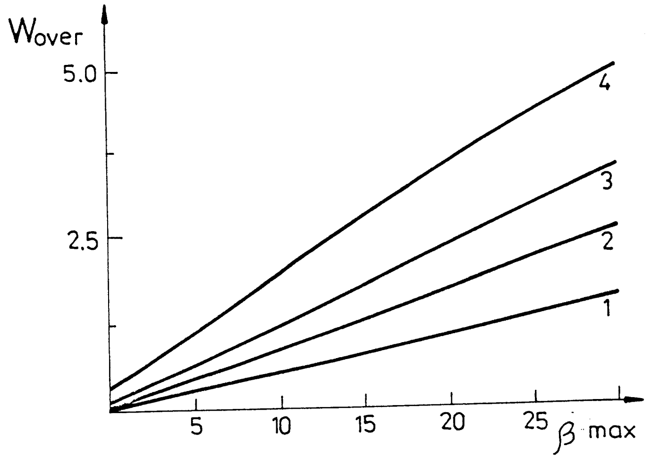

Figure 5. The dependence of $W_{over}(\beta_{max})$ vs. the angle β_{max} . The parameters are following: $n = 10^9$ cm^{-2}, h = 10 μm. The curves 1 - 4 correspond to D = 0.05, 0.75, 0.10 and 0.15 μm, respectively (variant 2).

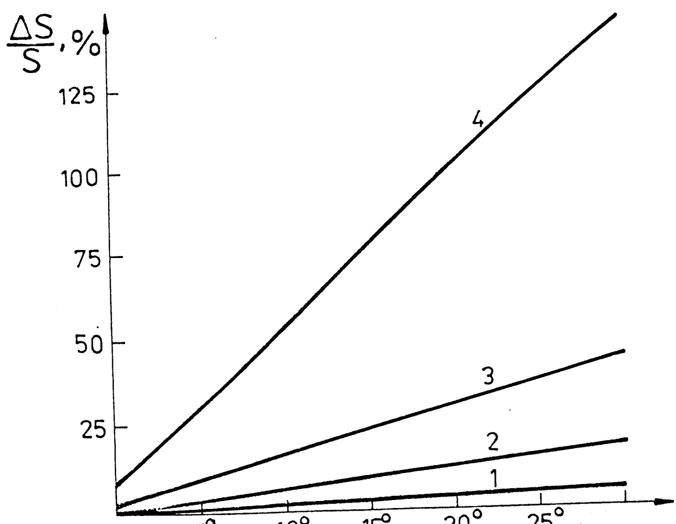

Figure 6. The dependencies of the relative volume area overlapping of pores (ΔS/S %) vs. the angle β_{max} are presented. Curves 1 - 4 correspond to the pore diameters D = 0.05, 0.075, 0.10 and 0.15 μm respectively (variant 2).

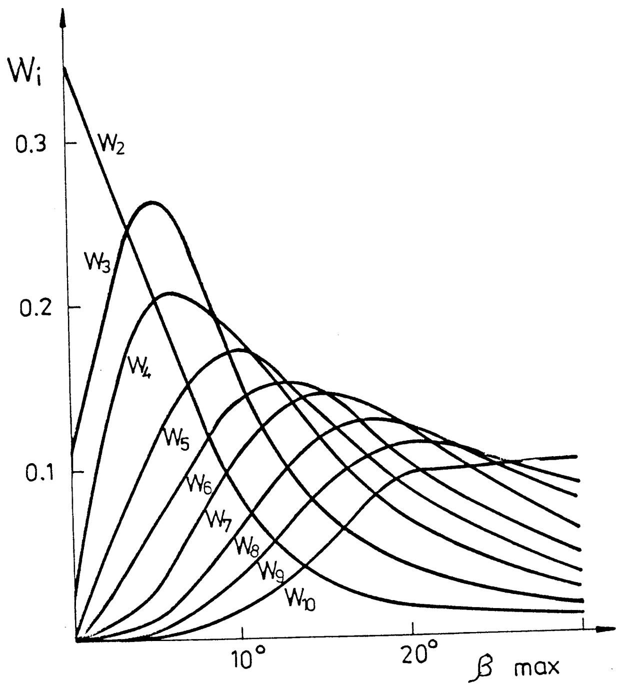

Figure 7. The probabilities of multi overlapping of holes (W_m, m=1,...,10) vs. the angles β_{max}. The parameters were the following: D= 0.15 μm, n= 10^9 cm^{-2}, h= 10 μm (variant 2).

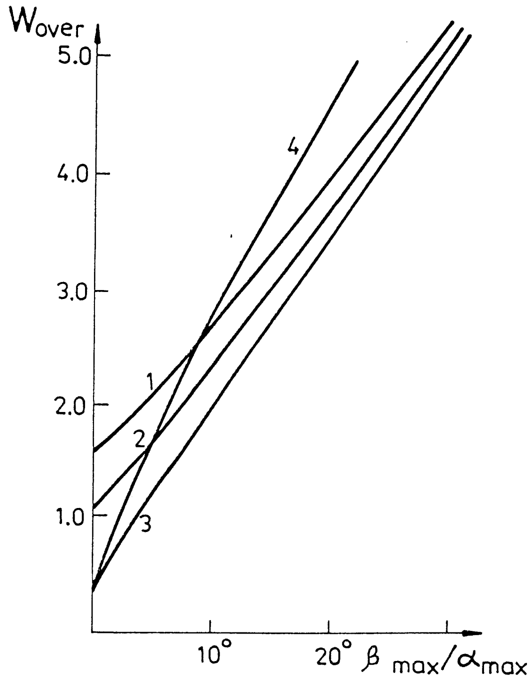

Figure 8. The dependencies of $W_{over}(\beta_{max})$ vs. the angle β_{max}. The curves 1 - 3 correspond to the $\alpha_{max} = 5^0$, $\alpha_{max} = 3^0$ and $\alpha_{max} = 0^0$ respectively. Curve 4 is the dependence of $W_{over}(\alpha_{max})$ vs. the angle α_{max} at the value of angle $\beta_{max} = 0^0$. The parameters here are the following: $n = 10^9$ cm^{-2}, $h = 10$ μm and the pore diameter is $D = 0.15$ μm (variant 3).

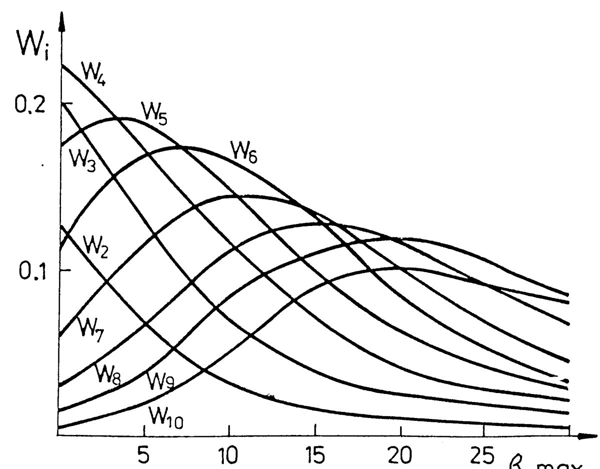

Figure 9. The probabilities of multi overlapping of holes (W_m, m=1,...,10) vs. the angles β_{max}. The parameters of calculations were the following: $D = 0.15$ μm, $n = 10^9$ cm^{-2}, $h = 10$ μm and $\alpha_{max} = 5^0$ (variant 3).

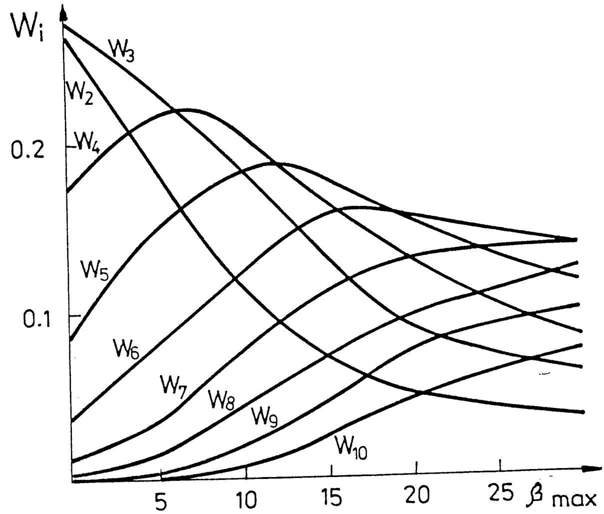

Figure 10.The probabilities of multi overlapping of holes (W_m, m=1,...,10) vs. the angles β_{max}. The parameters of calculations were the following: D = 0.10 μm, n = 10^9 cm^{-2}, h = 10 μm and $\alpha_{max} = 5^0$ (variant 3).

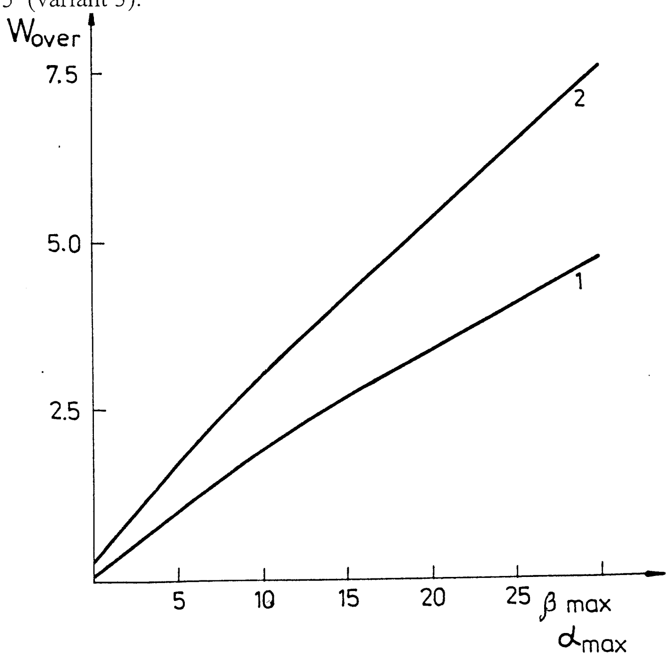

Figure 11. The dependencies of $W_{over}(\beta_{max},\alpha_{max})$ vs. the angle $\beta_{max} = \alpha_{max}$. The curves 1 - 2 correspond to the pore diameters D = 0.10 and 0.15 μm respectively. The parameters here are the following: n = 10^9 cm^{-2}, h = 10 μm (Three-dimensional angle distribution - variant 4).

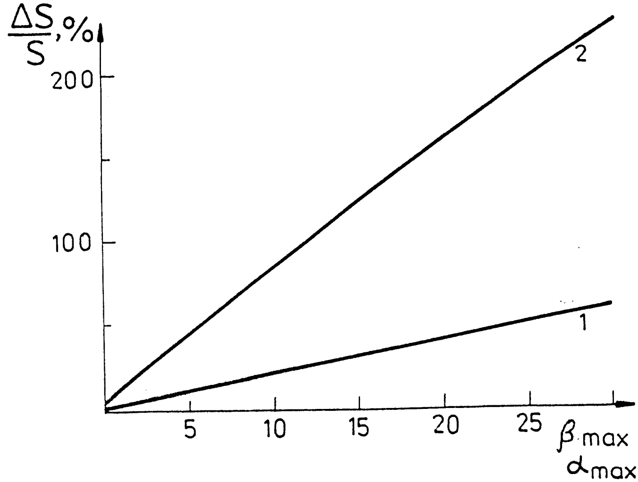

Figure 12. The dependencies of the relative volume area overlapping of pores (ΔS/S %) vs. the angle $\beta_{max} = \alpha_{max}$ are presented. Curves 1 - 2 correspond to the pore diameters D = 0.10 and 0.15 μm respectively (Three dimensional angle distribution - variant 4).

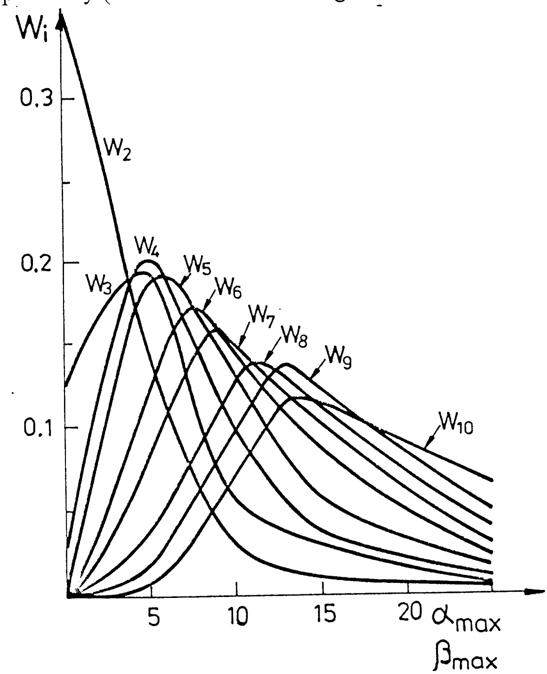

Figure 13. The probabilities of multi overlapping of holes (W_m, m=1,...,10) vs. the angles β_{max} and α_{max}. The parameters of calculations were the following: D = 0.15 μm, n = 10^9 cm^{-2}, h = 10 μm (Three dimensional angle distribution - variant 4).

As very easy to see at low angles the differences between $W_{over}(\alpha_{max}, \beta_{max} = 0^0)$ as a function of α_{max} are much more than between $W_{over}(\alpha_{max}, \beta_{max})$ with the following grow of α_{max}. Also one can conclude that three dimensional angle distribution better in comparison with the other distributions, because $W_{over}(\alpha_{max} = \beta_{max} = 30^0) = 7.5$ and $\Delta S/S = 230$ %, but for case of the production (irradiation) of polymeric foils by high energy heavy ions on accelerators variant 3 is not so differs.

The method presented here allows to predict the value of W_{over} for various multi-plan angular distributions and as a result will be successful for the estimations of such interconnections on diffusive and convective flow rates of fluids and gases. Also it is possible to choose the necessary kind of distributions of multi overlapping holes for the following production of TM.

The scheme developed here may be used not only for the cylindrical geometry of hole structure but for the holes with the complex hole shapes too.

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Перекрытие треков ионов в трековых мембранах с различными угловыми распределениями ионов

Представлены результаты по расчету плотности пересечений треков пор в зависимости от пористости трековых мембран для возможных конфигураций угловых зависимостей углов входа ионов.

Работа выполнена в Лаборатории ядерных реакций им. Г.Н.Флерова ОИЯИ.

Сообщение Объединенного института ядерных исследований. Дубна, 2000

Didyk A.Yu., Vutsadakis V., Dmitriev S.N. E14-2000-41
Volume Interconnection Rates in Track Etched Membranes with Various Angular Distributions

The results of volume interconnections pore versus of porosity of track membranes are presented for various angle distribution of ion impact passing.

The investigation has been performed at the Flerov Laboratory of Nuclear Reactions, JINR.

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