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QUARTERLY REPORT

TRENDS AND TECHNIQUES FOR SPACE BASE ELECTRONICS

Prepared by:

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Mississippi State, MS 39762

QUARTERLY REPORT

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Prepared by:

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for

NASA Contract NAS8-26749

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1. DOUBLE-LEVEL METALLIZATION TECHNIQUES

Most of the work during the first quarter was directed toward the development of a sputtering system for preparing aluminum and aluminum-alloy films. A photograph of the completed system is shown in Figure 1.1. Briefly, the system consists of the following.

The basic vacuum system is a Varian-NRC 6 inch oil diffusion and mechanical roughing pump equipped for automatic and manual operation. The diffusion pump is equipped for LN_2 cooling of the cold trap. The sputter gun and power supply were obtained from Sloan Technology. The sputtering chamber was designed and built at Mississippi State. It consists of a Corning 12X18 glass cylinder and an aluminum top plate machined to accomodate up to three sputter guns. A cold cathode discharge gauge was constructed and installed in the baseplate of the chamber to measure the pressure during the sputtering operation. A throttle valve with several threaded holes for accomodating plugs is operated by one of two mechanical feedthroughs in the baseplate. A lift mechanism with a reversible motor was designed and constructed for raising the top plate and sputter guns.

Inside the chamber is equipped with a rotating table which accomodates up to eight wafers of 1½-2" in diameter. The table is driven by a vacuum sealed shaded pole motor through a magnetic coupling at 7 rpm. The entire motor-table assembly is rotated by a chain-sprocket-mechanical feedthrough arrangement through three sputter-gun and two mask positions. The mask is attached to the rotating assembly and provides one hole through which the sputter-gun deposits metal on the wafers. A crystal film thicknes sensor is located beneath the sputter-gun and receives a deposit through a hole at an unused wafer position on the table.

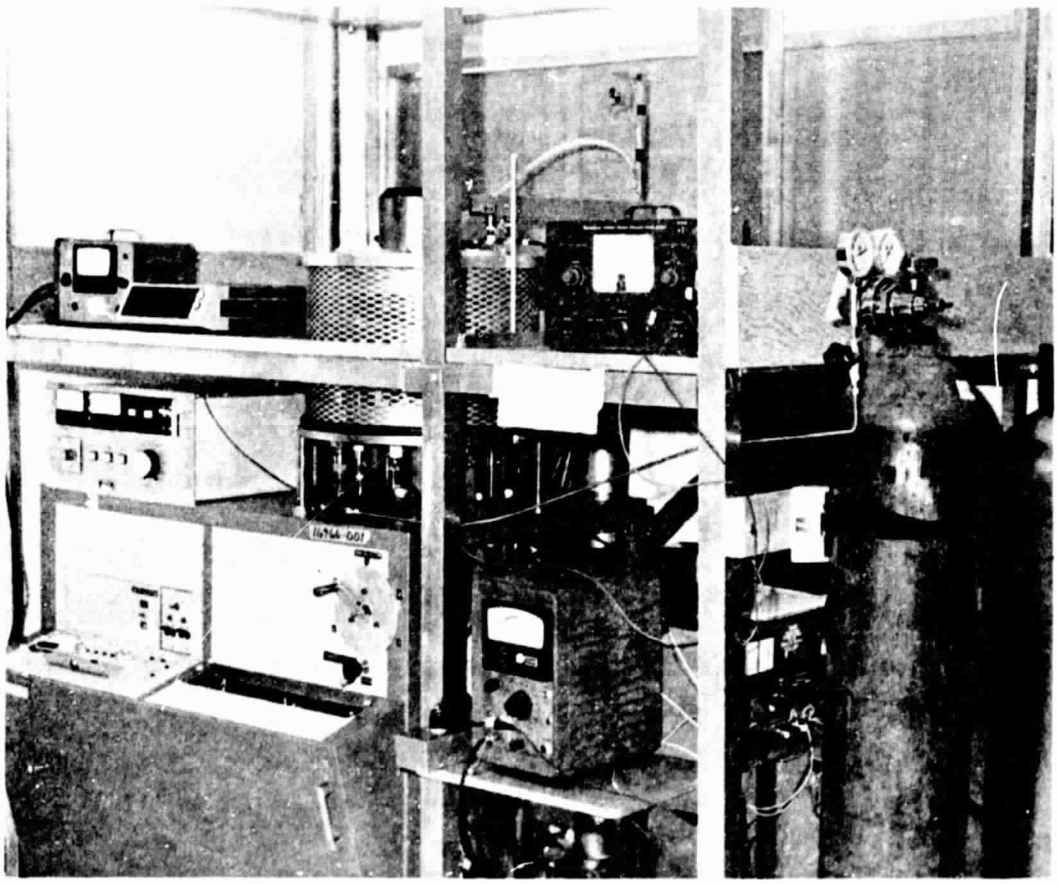


Figure 1.1 Photograph of metallization system using sputter-gun source.

The sputtering chamber opens into a class 100 clean bench in order to maintain a high level of cleanliness. The system is located in the metallizing and bonding room of the microelectronics laboratories in Simrall Engineering Building, and this room was designed with air conditioning and filtering units to maintain a class 30,000 environment. The entire system has been constructed and checked out and is ready for depositing sputtered films.

The installation of a six-tube Thermco Ranger diffusion furnace was completed with the addition of a venting system for exhausting the scavenger boxes. All that remains to be done is to line the tube and connect the nitrogen ambient source in order to anneal the aluminum films.

2. TWO-DIMENSIONAL MODELS FOR MOS TRANSISTORS

The work done during the first quarter was directed toward preliminary investigations of numerical schemes and computational algorithms for solving the semiconduction equations for a two-dimensional field.

A recent report has described the application of the finite-element method to the analysis of a JFET.[1] The finite-element method has been used for some time in solving problems in mechanics and elasticity; however, it has only recently been applied to semiconduction problems. This method has the power to treat some problems, such as eigen-value problems, for which the finite-difference method is awkward if at all applicable. It can also be applied to the solution of field distributions governed by partial differential equations, and one of the most attractive features as compared to the finite-element method is purported to be the ease of treating non-rectangular geometries and irregular boundaries. For example, the geometry of the VMOS structure could be accomodated. It was decided to further investigate this technique.

In order to better understand the applicability of the method, it was applied to a one-dimensional linear diffusion problem. This simple problem is one for which familiar results are available for comparison and at the same time taxes the finite-element method. In its most valid form, the finite element method is applicable to variational problems in which a true minimum of an energy-related function exists. Such a minimum does not apply for the semiconductor problem in which current flow occurs by diffusive and conductive mechanisms. It has been proposed that a "weak form", the so-called Galerkin method, be applied to such problems.[2] The typical semiconductor problem is a non-linear boundary value and initial condition problem of which the linear diffusion problem is a very special case. In the example chosen, the diffusion variable, u, obeys:

$$u(x,t)|_{x=0} = u_s = 1 \qquad (a) \qquad (2.1)$$

$$u_x(x,t)|_{x=a} = 0 \qquad (b)$$

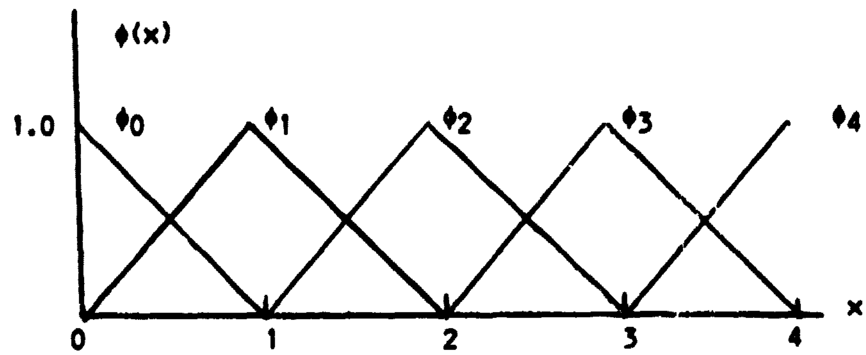
$$u(x,t)|_{t=0} = \begin{cases} 1, & x=0 \\ 0, & x>0 \end{cases} \qquad (c)$$

$$u_t - u_{xx} = f(x,t) = 0 \qquad 0\leq x\leq a \qquad (2.2)$$

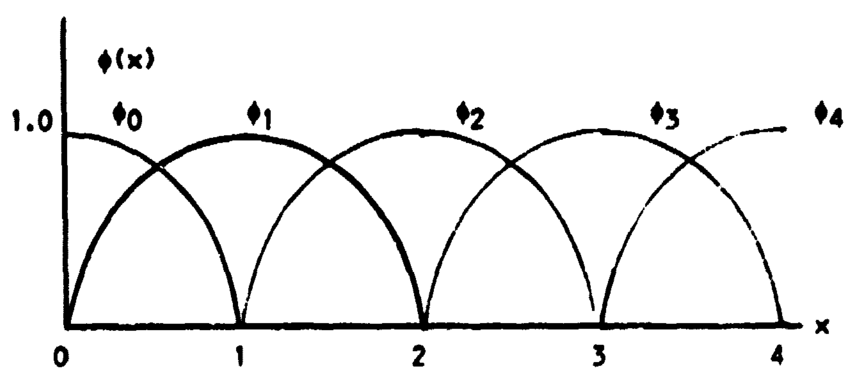
The Galerkin formulation of this problem is:

$$\int_0^a (u_t v - u_x v_x - fv) \, dx = 0, \qquad (2.3)$$

where v(x,t) represents a "trial function" which is used to approximate u(x,t). The finite element methods uses a set of "hill functions" as illustrated in Figure 2.1 to construct the v(x,t) approximation. Two of the popular hill functions are the Hermite bicubic and the bilinear functions which are illustrated in the figure and were used in the example. The final form of the approximate solution is;



(a) Bilinear hill functions



(b) Bicubic (Hermite) hill functions

Figure 2.1 Illustration of hill functions used in finite element method.

$$v(x,t) = \sum_{i=1}^{N} q_i(t)\ \phi_i(x)\ . \qquad (2.4)$$

On the node points the solution is approximated by the set $\{q_i(t)\}$ for the type of hill functions which overlap as illustrated in Figure 2.1. Solution for the set $\{q_i(t)\}$ is then analogous to solving for the set $\{u_i(t)\}$ on the node points using the finite difference technique. The equations for the set $\{q_i(t)\}$ are obtained by substituting (2.4) into (2.3).

$$\sum_{i=1}^{N} \int_0^a \left(\frac{\partial q_i}{\partial t} \phi_i \phi_j + q_i \frac{\partial \phi_i}{\partial x}\frac{\partial \phi_j}{\partial x} + f\phi_j \right) dx = 0$$

$$j = 1,2,3,\ldots\ldots N \qquad (2.5)$$

From (2.5) a set of time differential equations is obtained which is solved using an implicit numerical method.

The solution of the problem posed by the example is closely approximated by the erfc function in the range $0 \leq x \leq 3$ if $a = 6$, and this solution was used to compare the accuracy of the finite element and finite difference methods. Figures 2.2-2.4 show the maximum error as a function of the reciprocal of the number of grid points and the size of the time step, i.e. $\lambda^2 = \Delta t/\Delta x^2$.

The error obtained in the solution by the bilinear finite element method is very nearly the same as that obtained with the finite difference method. This was not surprising because the system of equations for $\{q_i(t)\}$ and $\{u_i(t)\}$ were quite similar. What was surprising was that the Hermite bicubic finite element produced such poor results, although this surprize was based upon the intuition that since this element was more difficult to use it should provide some reward for the difficulty.

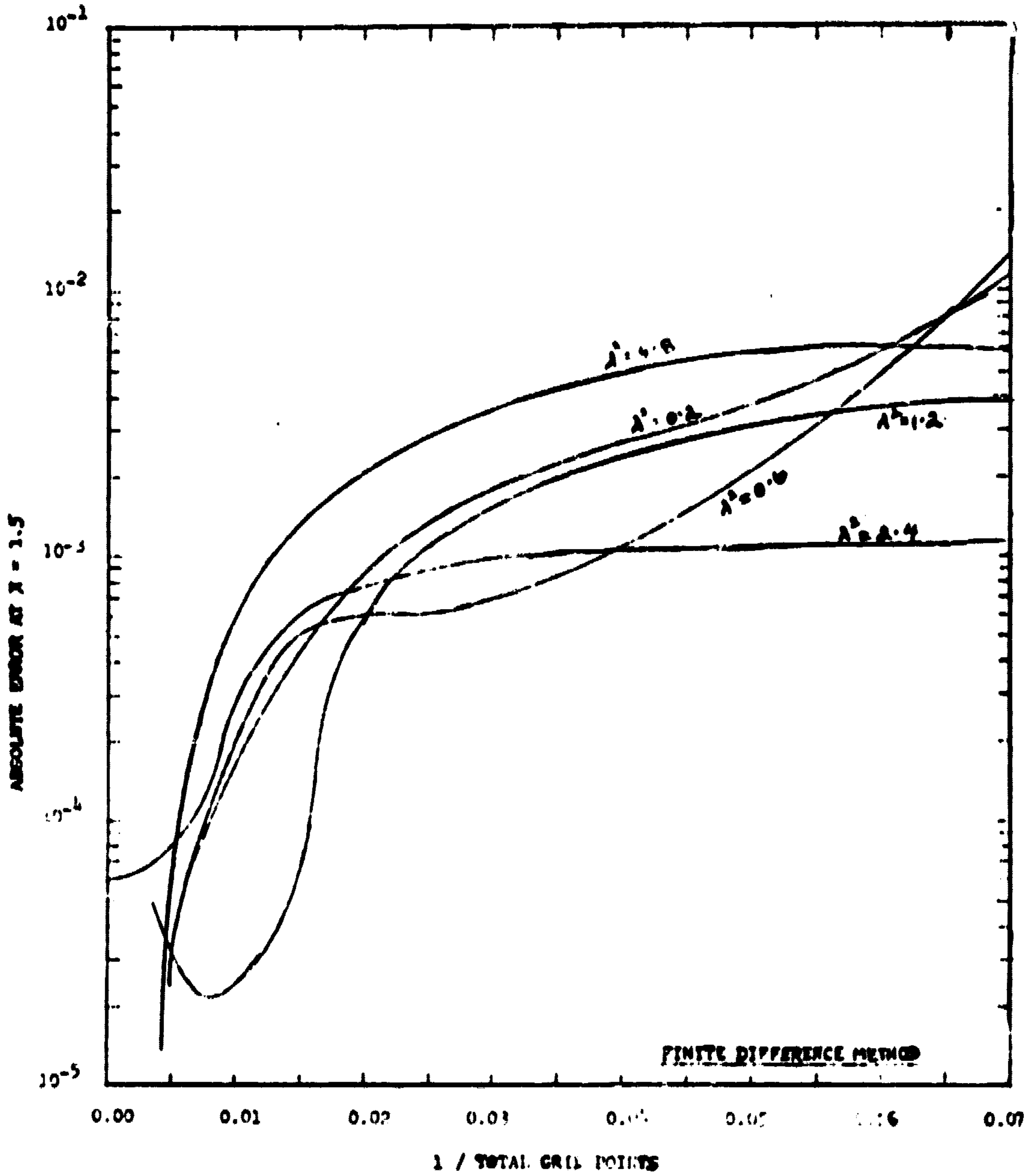


Figure 2.2 Error for finite-difference vs. reciprocal of total number of grid points.

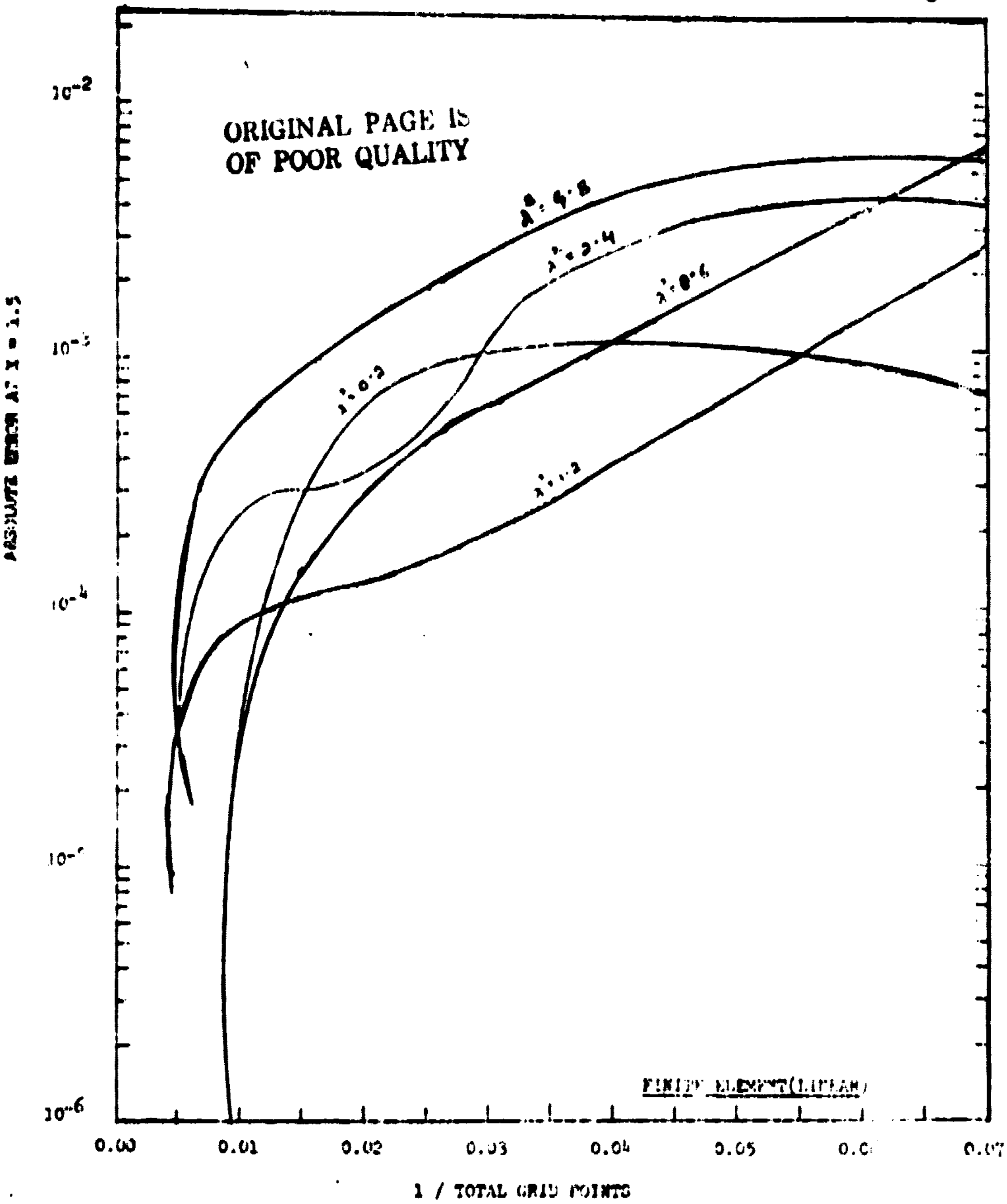


Figure 2.3 Error for finite-bilinear element vs. reciprocal of total number of grid points.

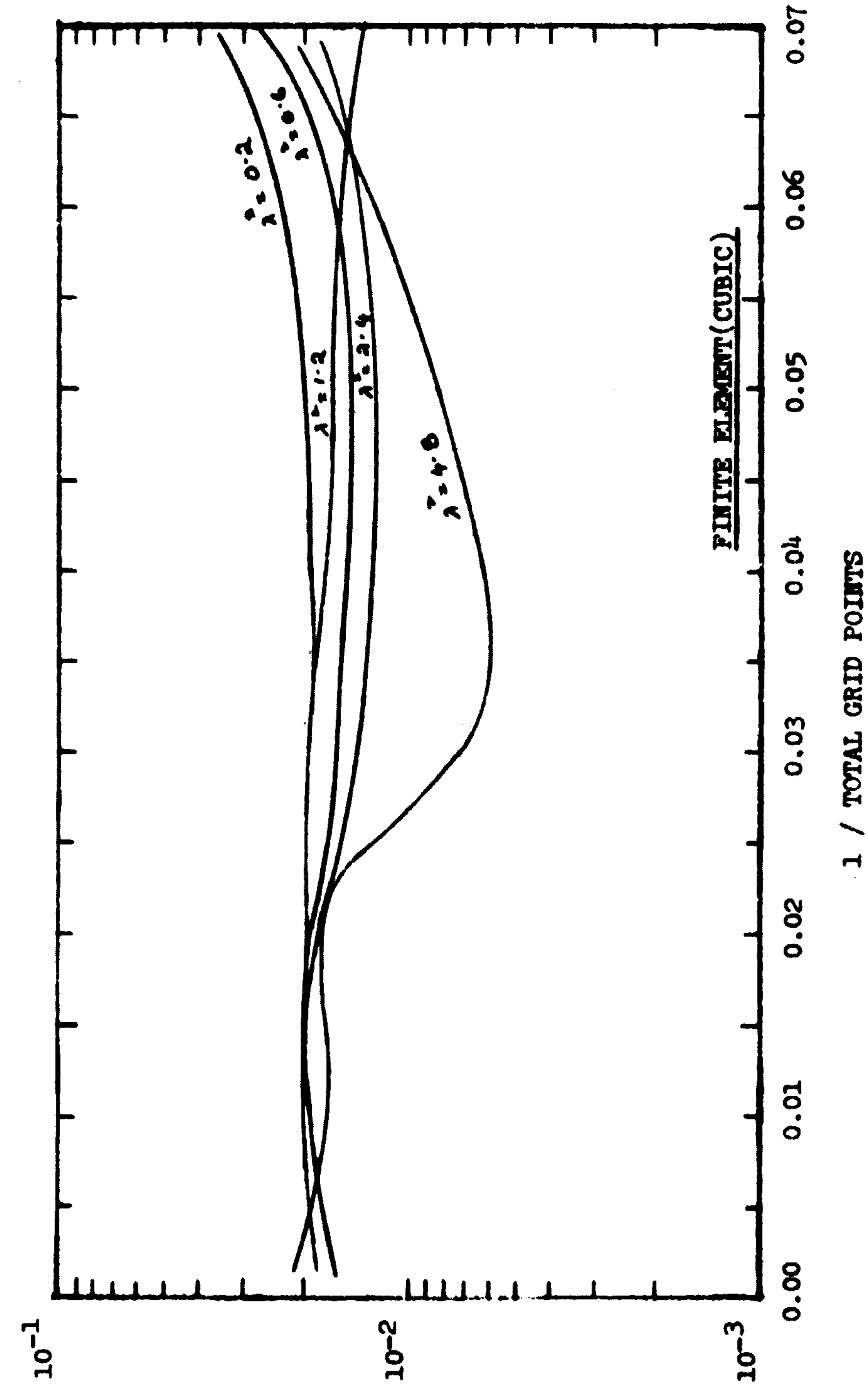


Figure 2.4 Error for finite-bicubic-element vs. reciprocal of total number of grid points.

This experience resulted in some skepticism that the finite element method would be effective for semiconductor problems. A more recent paper has reinforced this attitude.[3] This paper indicates that the proper formulations of the semiconductor problem for the finite element approach remain to be demonstrated, and, in agreement with our observations, point out that the application of Galerkin's method is subject to skepticism. Therefore, it was concluded that the further work should be based upon the finite-difference method which we have used before although the finite-element method is intriguing and may be further developed in the future.

The second phase of this program is underway to develop a computational program with which to generate data from a model. During the past quarter, the major emphasis was upon deriving a simple two-dimensional algorithm which could be economically used in a simulation program during its development. It is plausible that this algorithm can be later modified to become adequate for modeling of other effects which are significant in certain situations, e.g., short channel effects, avalanche breakdown, etc.

During the past quarter an algorithm has been developed based upon the usual assumption that the mobile carriers are included in an infinitesimally thick layer of charge at the $Si-SiO_2$ interface. The current flow is then described by a one-dimensional equation:

$$i = \frac{kT}{q} \mu_N \left(\frac{\partial \mu_L S}{\partial X} + \frac{q\mu_L}{kT} E_s S \right) , \quad 0 \leq x \leq a \quad (2.6)$$

where i and S are channel current and charge per unit channel width, E_s is the tangential interface field and μ_N and μ_L are the mobility factors accounting respectively for gate modulation and hot electron effects. This equation is solved iteratively with Poisson's equation which includes two-dimensional effects:

$$\nabla^2\Psi = -\rho/\varepsilon. \qquad (2.7)$$

Equation (2.7) will be solved for one segment of a periodic structure with respect to x and equation (2.6) will be integrated to produce auxiliary equations for the boundary conditions at the Si-SiO_2 interface. It will be assumed initially that S = 0 at x = a, the point at which the normal component of the interface field changes sign. The solution algorithm then proceeds in an iterative fashion to solve (2.6) and (2.7) simultaneously for the potential distribution from which the current, I, is ultimately calculated as a function of the gate, drain and body voltage .

The model at this point admittedly has some short-comings, mainly due to the neglection of generation-recombination mechanisms. Therefore, it will not treat impact avalanche and bulk generated leakage currents. It is believed at this time that such effects can be treated by adding another iterative loop to the algorithm. The major emphasis at this point will be the development of a program for input and output data management and including subroutines which generate data internally within the program and solve systems of equations which will be encountered in implementing the algorithm.

3. REDISTRIBUTION DIFFUSIONS FOR ION-IMPLANTED PREDEPOSITS OF BORON AND PHOSPHORUS IN SOS FILMS.

The objective of this work was to produce curves describing the variation with diffusion time and temperature of the junction depth, sheet resistance and integrated impurity dose. This data has been generated for boron and phosphorus redistributed in nitrogen, dry oxygen and steam ambients for <111> oriented SOS films. The following section presents discussions of the implantation and redistribution model, further program develop, the computational procedure and of the computed results.

3.1 The Redistribution Model:

There are three aspects of the redistribution model which are considered: (a) the implanted profile, (b) the oxidation model, and (c) the diffusivity model.

(a) The implanted profile.

The implanted profile is described by the gaussian function,

$$C(y) = C_{max} \exp \{-\tfrac{1}{2}\left(\frac{y - R_p}{\Delta R_p}\right)^2\} , \quad (3.1)$$

where C is the concentration, y is the distance from the entrant silicon surface, R_p is the range and ΔR_p is the straggle for the implant. The peak concentration, C_{max}, is related to the implant dose, Q_{imp} by:

$$C_{max} = Q_{imp} / \sqrt{2\pi}\, \Delta R_p \quad . \qquad (3.2)$$

Redistribution data has been generated for the following conditions:[4]

Q_{imp}:	5×10^{12} , 10^{13} , 5×10^{13} , 10^{14} cm^{-2}	
R_p:	0.2735 μm	80 keV boron implant.
	0.1727 "	150 keV phosphorus.
ΔR_p:	0.0665 μm	80 keV boron implant.
	0.0440 "	150 keV phosphorus.

The doses are light to moderate resulting in concentrations no heavier than 6×10^{18} cm^{-3}, and the range-straggle values are typical of those employed at MSFC. It is assumed that all of the ions become activated shortly after redistribution begins and thereby diffuse by a substitutional mechanism involving vacancies.

(b) Oxidation model:

The oxidation model is assumed to be the same as for bulk silicon and the data of Deal et. al.[5] has been used to calculate the oxidation rate according to:

$$\frac{dx_o}{dt} = B/(2x_o + B/C), \qquad (3.3)$$

where B and C follow Boltzmann-like temperature dependences. Figures (3.1) and (3.2) illustrate the oxide thickness dependence upon time and temperature for both dry O_2 and steam ambients.

During the oxidation, the silicon film thickness is reduced according to:

$$W = W_o - \alpha x_o, \qquad (3.4)$$

where W_o is the initial film thickness, taken to be 1 μm, and $\alpha = 0.45$ is the ratio of the densities of SiO_2 to silicon. Redistribution data is given for W_o = 1 μm and an initial oxide thickness of x_o = 300 Å.

(c) Diffusivity model:

The diffusivity model for boron was discussed in an earlier report[6] and it includes a linear dependence of the diffusivity upon the vacancy concentration as well as the field-enhancement effect. The diffusivity model for phosphorus includes only the field-enhancement effect which is sufficient to describe the non-linear behavior of phosphorus diffusions at concentrations lower than 10^{19} cm^{-3} as shown by Barry[7] and Fair and Tsai[8]. The diffusivity-temperature dependence is after Fair[9] and Fair and Tsai[8] adaptation of data by Ghostagore[10]. For either boron or phosphorous the effective diffusivity is given by:

$$D_{eff} = D(u) \times (1 + u/ \sqrt{u^2 + 1}) , \quad (3.4)$$

where,

$$u = C/ 2 n_i, \quad (3.5)$$

and,

$$D(u) = D_B^* u, \text{ for boron,} \quad (3.6)$$
$$= D_P^* , \text{ for phosphorus.}$$

and where n_i is the intrinsic carrier concentration at the diffusion temperature and D_B^* and D_P^* are the intrinsic diffusivities of boron and phosphorus:

$$D_B^* = 3.17 \exp (-3.59eV/ k_B T) \ cm^2/sec. ,$$
$$D_P^* = 3.85 \exp (-3.66eV/ k_B T) \quad (3.7)$$

3.2 Further Program Development:

The program which was used to generate the data has been described in detail in an earlier report. It was noted that the program was developed in such a way that one could take advantage of a normalization procedure for predeposition diffusions and generate data applicable to different film thicknesses. However, it is not possible to gain such an advantage for re-distribution diffusions involving ion-implants or growth of an oxide. Then the program was used to generate data, it was discovered that some other features of the program are extraneous unless further refined.

The program was developed to account for both thin and thick oxides such as would be encountered in some practical situations. However, such a simulation requires the incorporation of a warped grid system, a modification which would require considerably more effort. Therefore, the variable oxide feature is of limited value at this time, since the program, at best, only approximates the conditions for growth of a very thin oxide during redistribution.

A modification was made which allows accurate treatment of redistribution under oxidizing conditions when only a single oxide thickness is involved. The original program treated the oxidation process with regard to the boundary conditions; however, unlike the case of bulk silicon, one must also account for the reduction of the silicon film thickness. This feature is now included in the program. During the simulation of a redistribution in an oxidizing ambient, the vertical grid spacing continuously shrinks while the horizontal grid spacing is constant. The modification does not show up on logic flow diagrams at the level of detail which has previously been given. For completeness, a new listing of the affected main and sub-programs is given in the appendix.

3.3 Computational Procedure:

The program described in an earlier report, and modified as described in the preceding, was used to generate the data. Two-dimensional data was obtained in the form of isoconcentration contours for typical situations. The bulk of the data which can be correlated with experimental measurements is generated using a quasi-one-dimensional model in a manner described in a previous report.[6] A brief review of the procedure is given in the following.

For generation of sheet resistance, junction depth and integrated impurity dose data as a function of time and temperature, only a one-dimensional profile need be calculated. This is accomplished by making the horizontal grid only three units wide but keeping the field six film thicknesses wide. Periodic boundary conditions for the horizontal dimensions are employed in the program and result in a calculation which produces the vertical profile equivalent to a none-dimensioni model. Thus without sacrificing the generality of the program for treating two-dimensional cases, the amount of computing time is drastically reduced when the data that is desired does not require the full power of the program.

The vertical grid varies from thirty one to sixty one points as required for accuracy in details of the profile, and most of the data is not sensitive to the number of grid points used if the number is chosen in this range. For the purpose of illustrating the unusual nature of phosphorous profiles, the larger number of points was required.

3.4 Discussion of Results:

First, some of the unusual behavior of redistribution diffusions in SOS films will be discussed in this section. Next, the format for the calculated curves will be discussed, and, finally, the bulk of the generated data is given in the appendix without further comment.

Figures (3.1) and (3.2) illustrate the oxide thickness growth and silicon film thickness reduction as functions of time for <111> silicon films oxidized in steam and dry O_2 ambients. The evolution traced beginning with an initial oxide of 300 Å thickness on an SOS film of 1 μm initial thickness. The curves are shwon for four temperatures. The data are necessary for interpreting some of the results for simulated redistributions.

Figures (3.3) and (3.4) show impurity profiles for boron and phosphorus implants being redistributed in a steam ambient at 1000 deg. C. The profiles are all plotted with a common origin as would be the case for experimentally derived profiles where the Si-SiO_2 interface would serve as the logical origin. However, the profiles are normalized with respect to the film thickness which

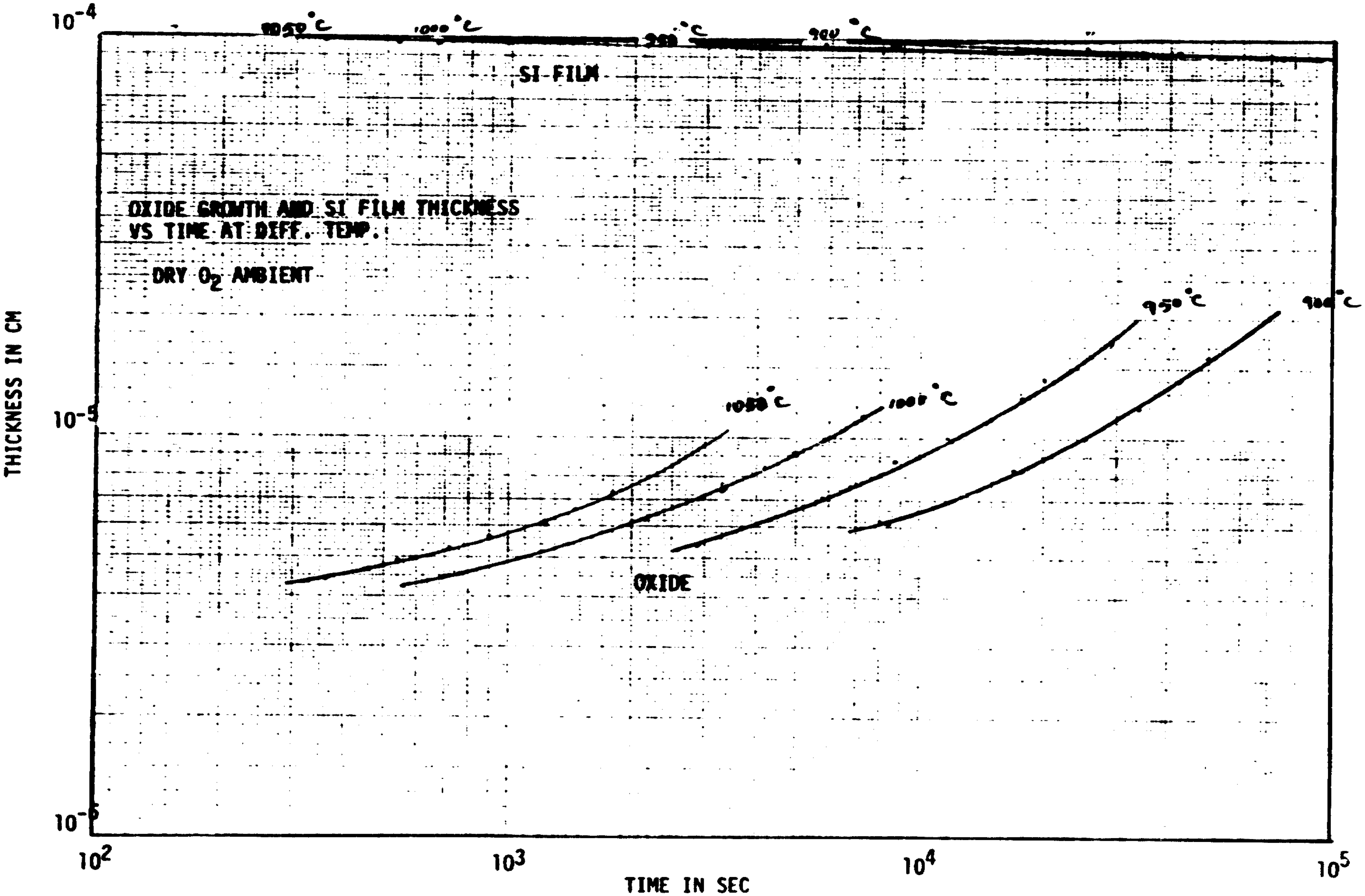

OXIDE GROWTH AND SI FILM THICKNESS
VS TIME AT DIFF. TEMP.
DRY O2 AMBIENT
SI FILM
OXIDE
1050°C
1000°C
950°C
900°C
THICKNESS IN CM
10^{-4}
10^{-5}
10^{-6}
10^2
10^3
10^4
10^5
TIME IN SEC

Figure 3.1

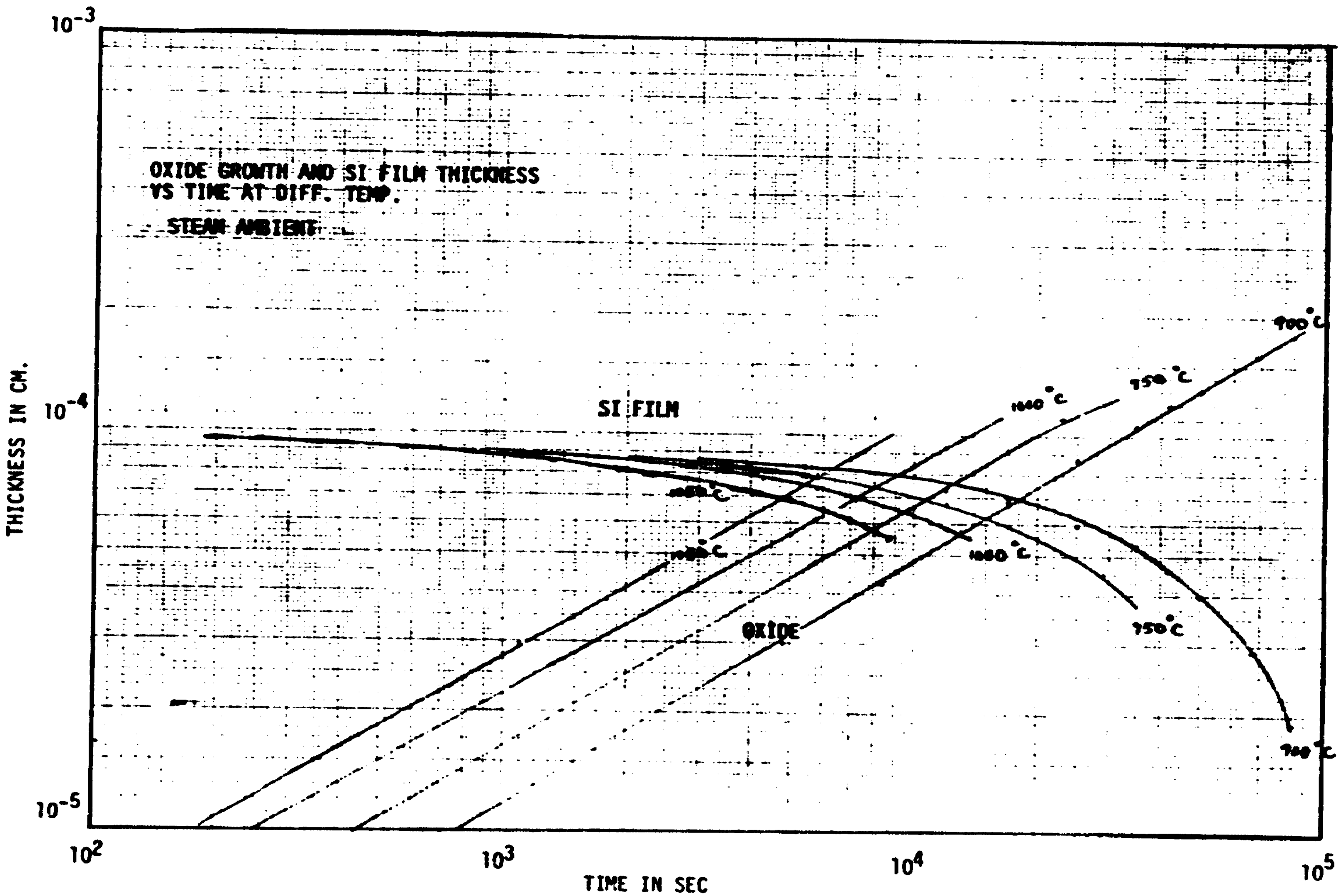

OXIDE GROWTH AND SI FILM THICKNESS
VS TIME AT DIFF. TEMP.
STEAM AMBIENT
SI FILM
OXIDE
900 °C
950 °C
1000 °C
1050 °C
THICKNESS IN CM.
TIME IN SEC
10^{-3}
10^{-4}
10^{-5}
10^{2}
10^{3}
10^{4}
10^{5}

Figure 3.2

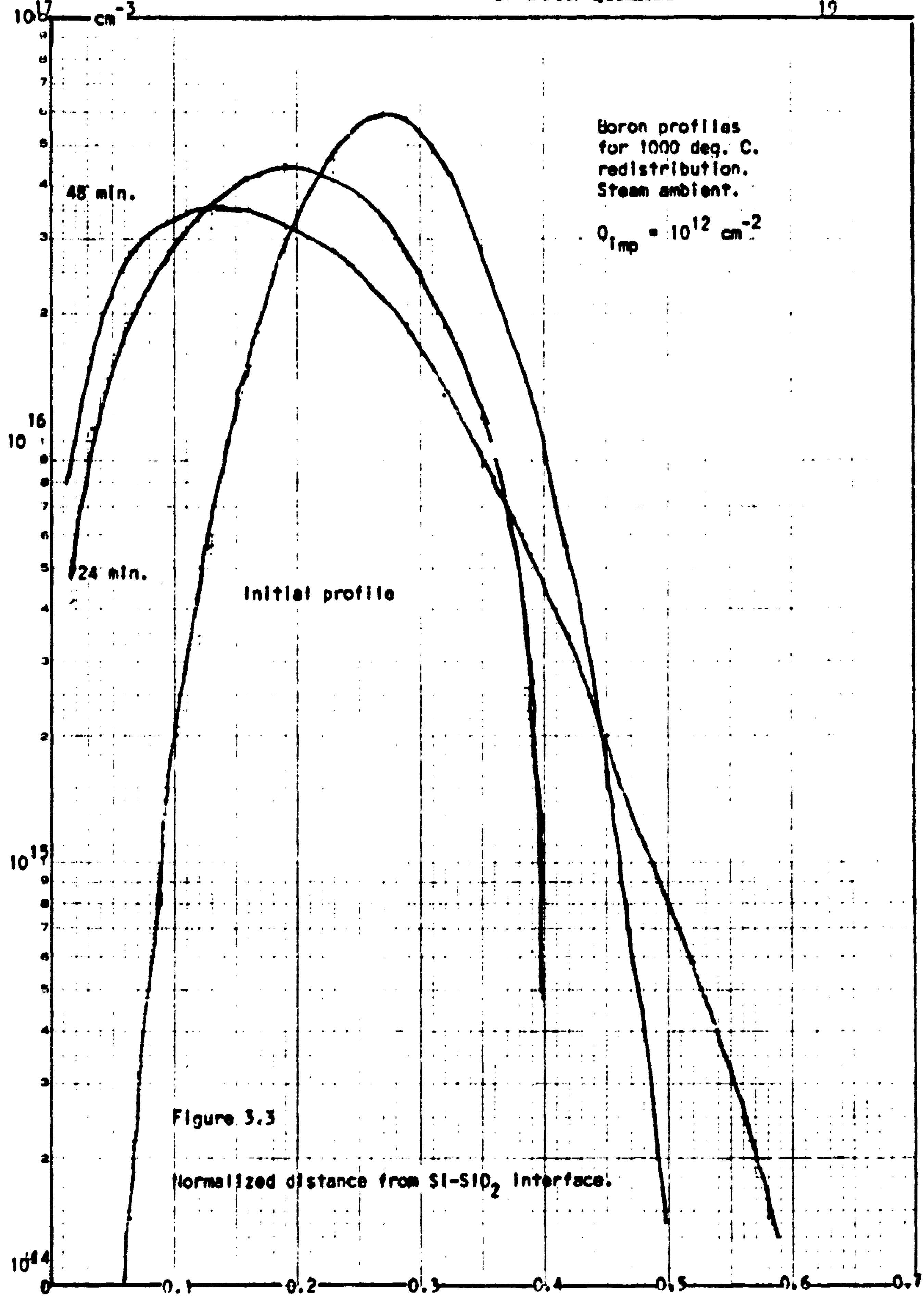
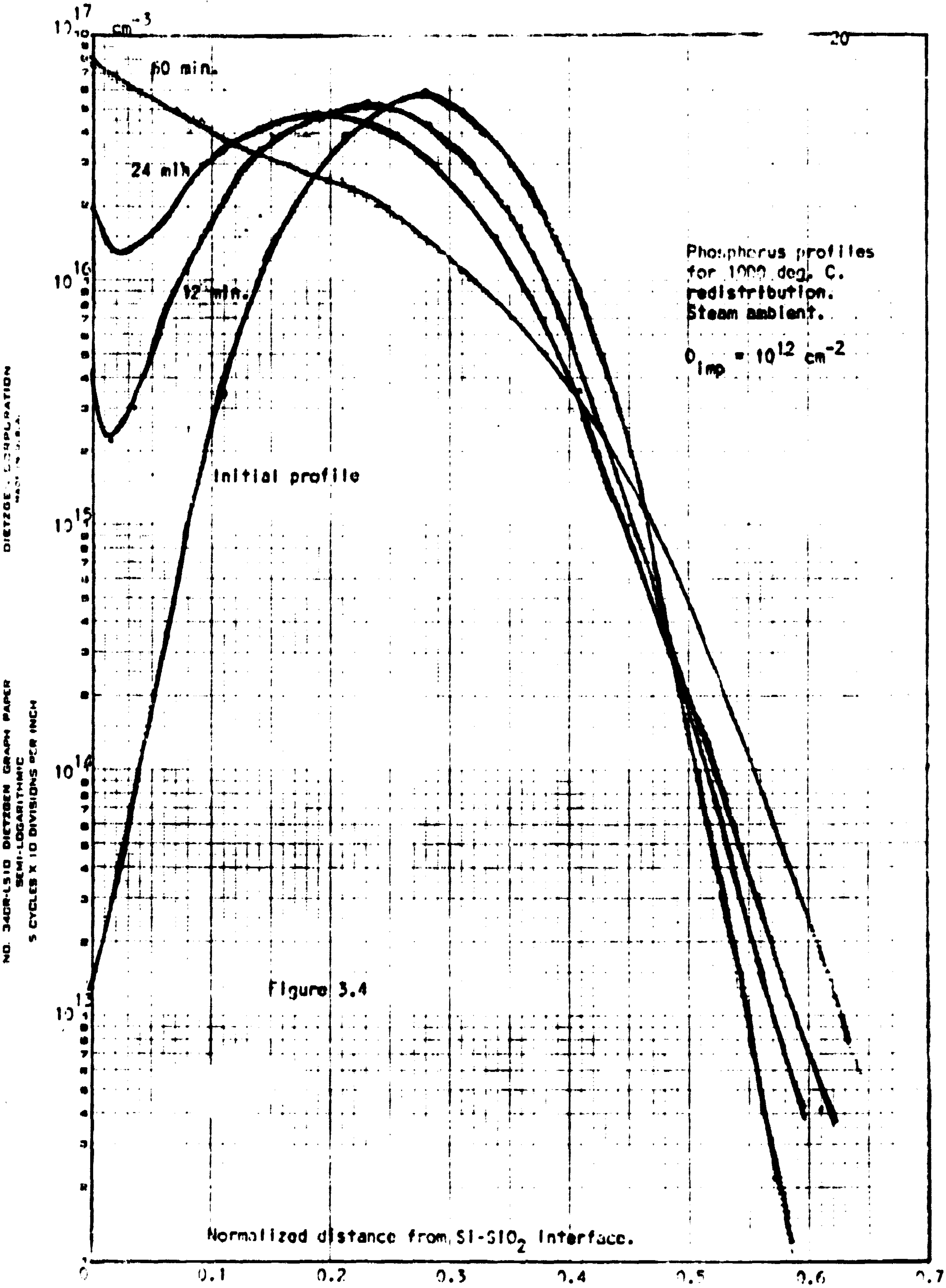


Figure 3.3

Normalized distance from $Si\text{-}SiO_2$ interface.



cm^-3
60 min.
24 min
12 min.
Initial profile
Phosphorus profiles for 1000 deg. C. redistribution. Steam ambient.
$Q_{imp} = 10^{12}$ cm^{-2}
10^{17}
10^{16}
10^{15}
10^{14}
10^{13}
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Normalized distance from Si-SiO2 interface.
NO. 340R-L510 DIETZGEN GRAPH PAPER
SEMI-LOGARITHMIC
5 CYCLES X 10 DIVISIONS PER INCH
DIETZGEN CORPORATION

Figure 3.4

is of course shrinking. The boron profiles are not unusual but show the well-known leaching effect due to segregation into the oxide. The phosphorus profiles show the effect of impurities being rejected from the oxide. There is a pile-up of impurities in front of the advancing Si-SiO_2 interface and then a dip which eventually disappears. It is easy for one to draw an erroneous conclusion from observing the profiles, because it appears that the integrated dose should increase for at least remain constant and the sheet resistance should decrease with time. This is not true. Although the segregation coefficient favors phosphorus in silicon vs. SiO_2, eventually all of the phosphorus will be in the SiO_2 when the SOS film is completely oxidized since the model assumes that there is no diffusion into the sapphire.

Figures (3.5-3.7) illustrate the behavior of the junction migration, sheet resistance variation, and integrated impurity dose variation over a long period of time. All of the curves are plotted with respect to normalized time, and true time is obtained by multiplying by the normalizeng time value given on the plot. Junction depths are in microns, sheet resistance values are in ohms, and dose values are in cm^{-2} units unless otherwise marked. The curves are given in the typical format for all of the data.

For an ion-implanted profile, there are in fact two junctions until one of the junctions emerges at the Si-SiO_2 interface. Therefore, the sheet resistance values are for the buried layer until the front junction disappears. This typically occurs in a short time compared with that for through-diffusion of the back junction. Figure (3.5) illustrates the through-diffusion of the back junction for the heavier doses. This always occurs for redistribution in a nitrogen ambient but not necessarily so for an oxidizing ambient. After the through diffusion, or even before for light doses, the junction depth will eventually decrease due to the reduction of the film thickness or due to the

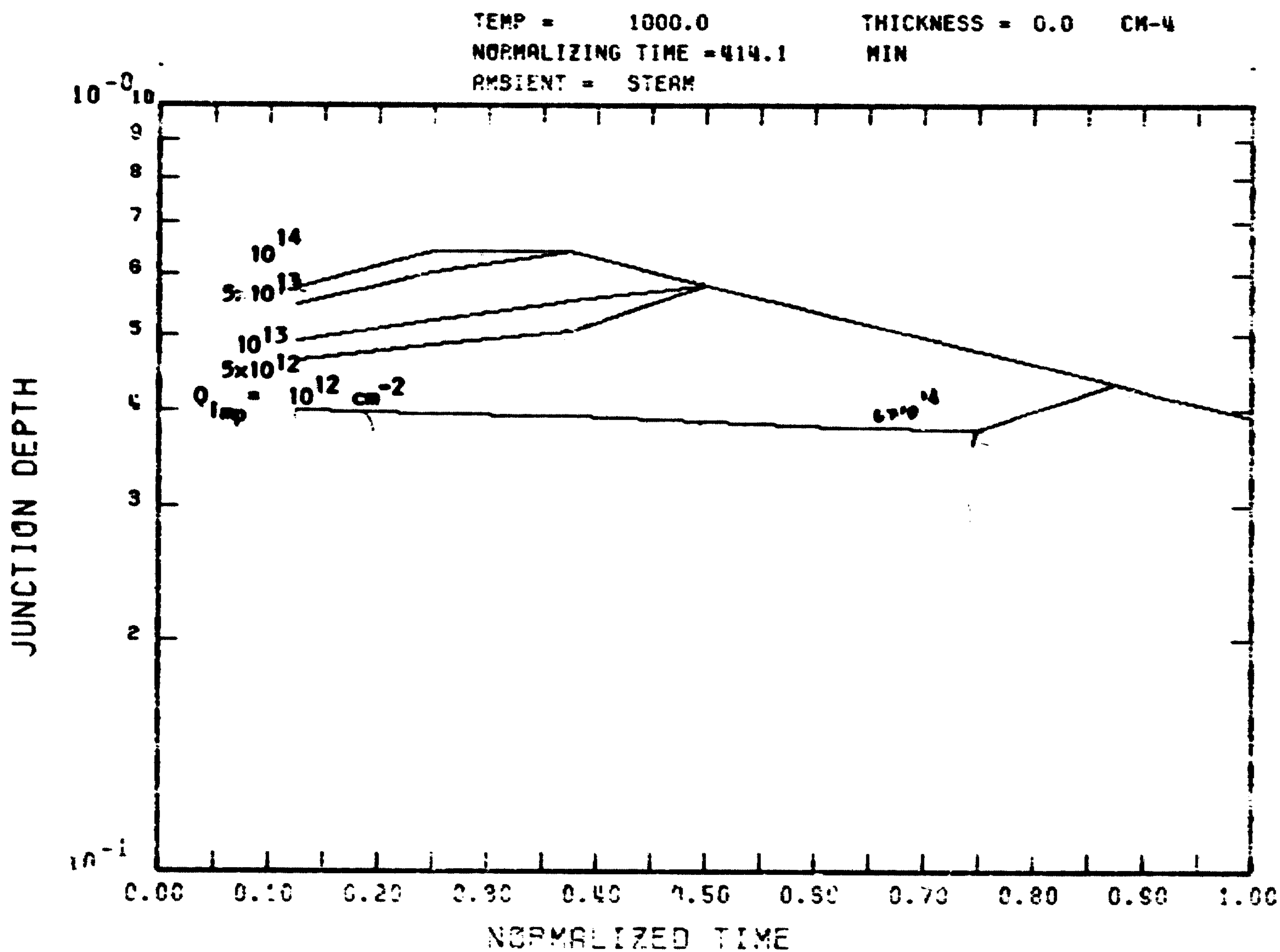


Figure 3.5 Junction position with respect to $Si\text{-}SiO_2$ interface for Boron redistribution.

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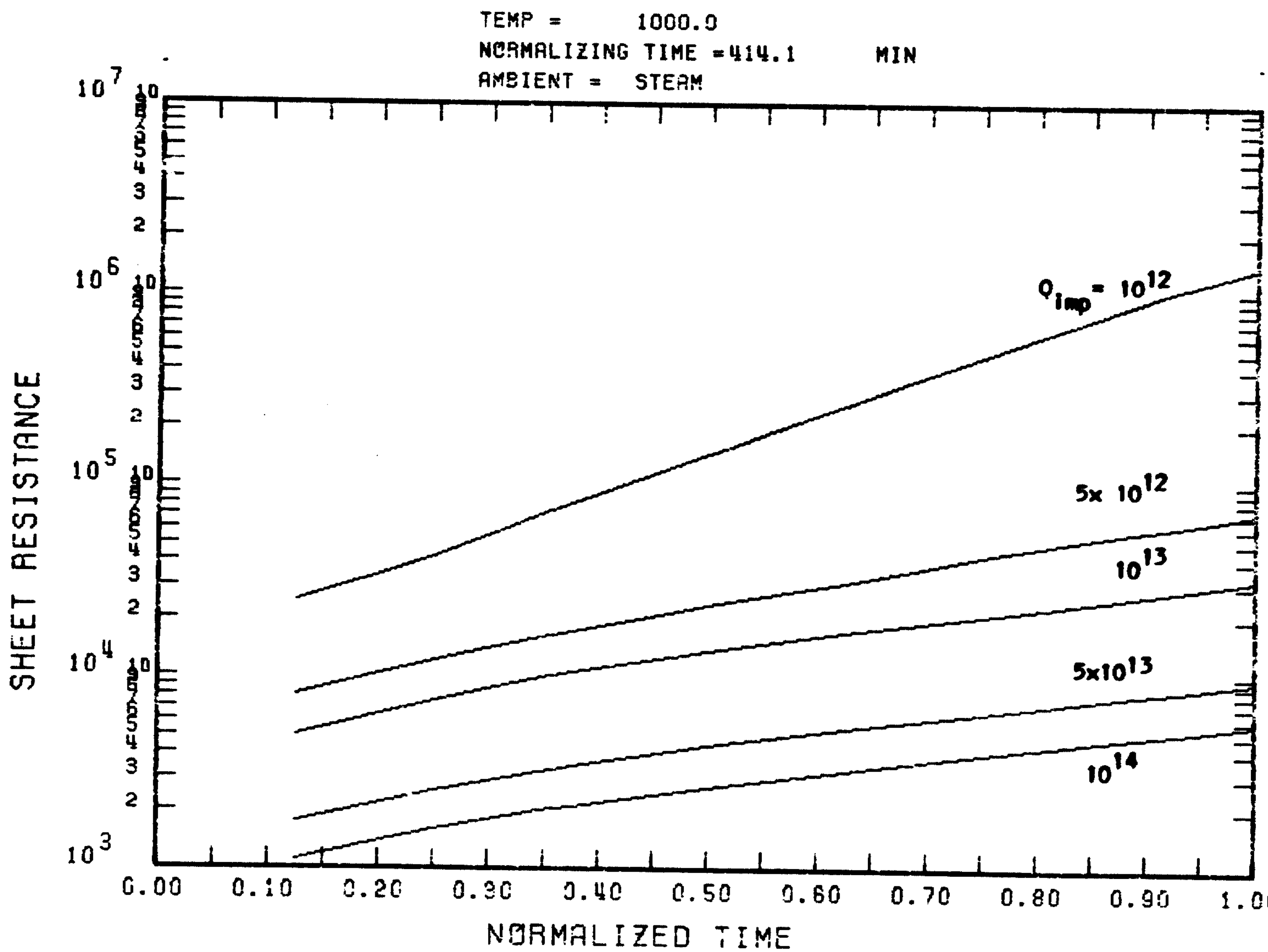

Figure 3.6 Sheet resistance for Boron redistribution.

B

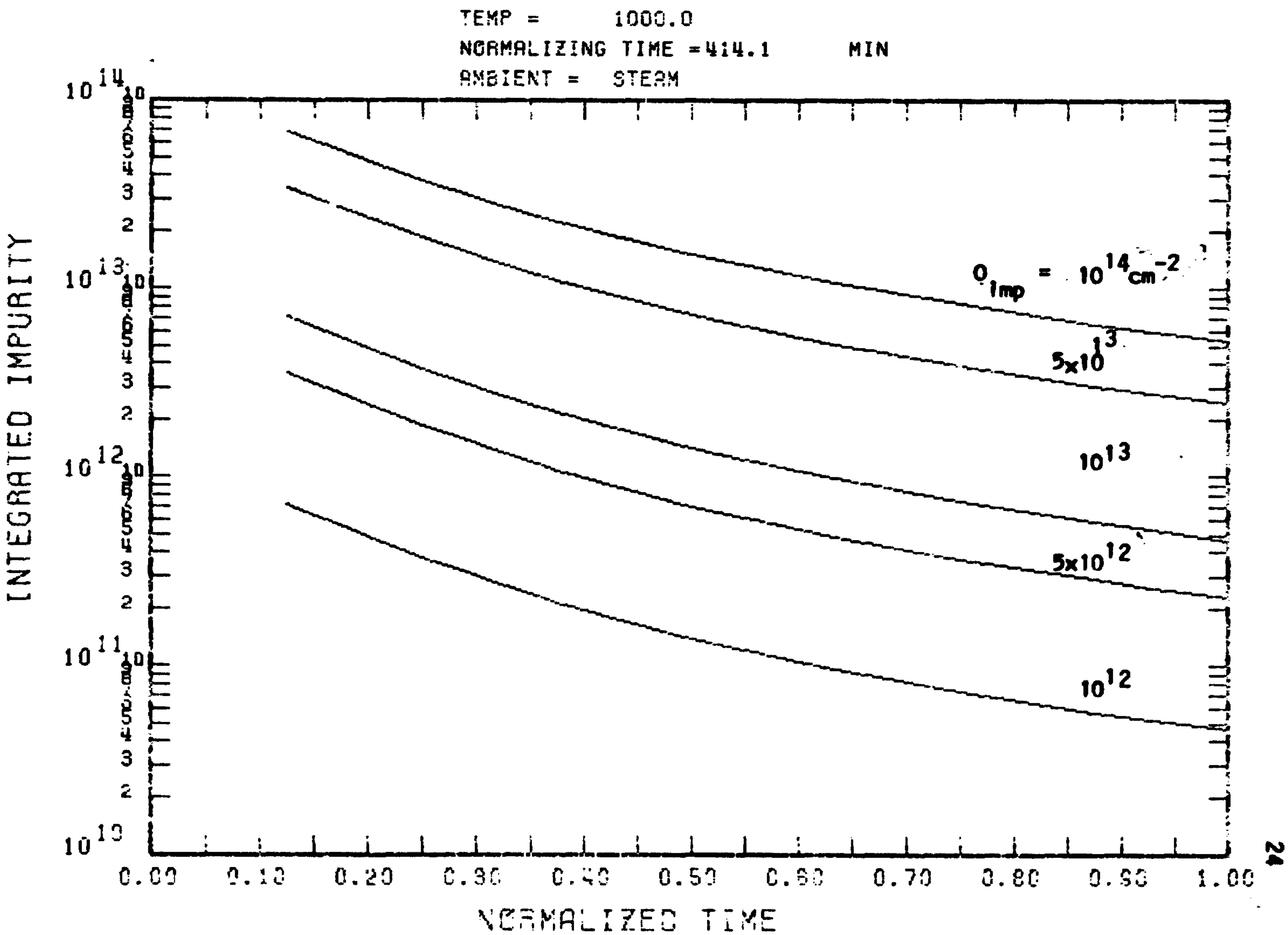

Figure 3.7 Variation of Dose for Boron redistribution.

relatively slow advancement of the junction with respect to the moving Si-SiO_2 interface. In some of the data presented in the appendix, the junction appears to remain almost stationary for this same reason. The variation of the sheet resistance and dose with redistribution time also may appear strange when compared with results for bulk silicon; however, consideration of the previously mentioned factors also explains these results.

Two-dimensional isoconcentration contours are given in the appendix for the various ambients and the two impurity types. The results are not as remarkable as those given in the last report which were for chemically pre-deposited boron. In that case, there was initially a heavy concentration of fast diffusing impurities at the Si-SiO_2 interface which were strongly retarded due to the segregation phenomena. This does not happen with the ion-implanted predeposit because the initial profile lies below the interface at which the segregation phenomena is effective.

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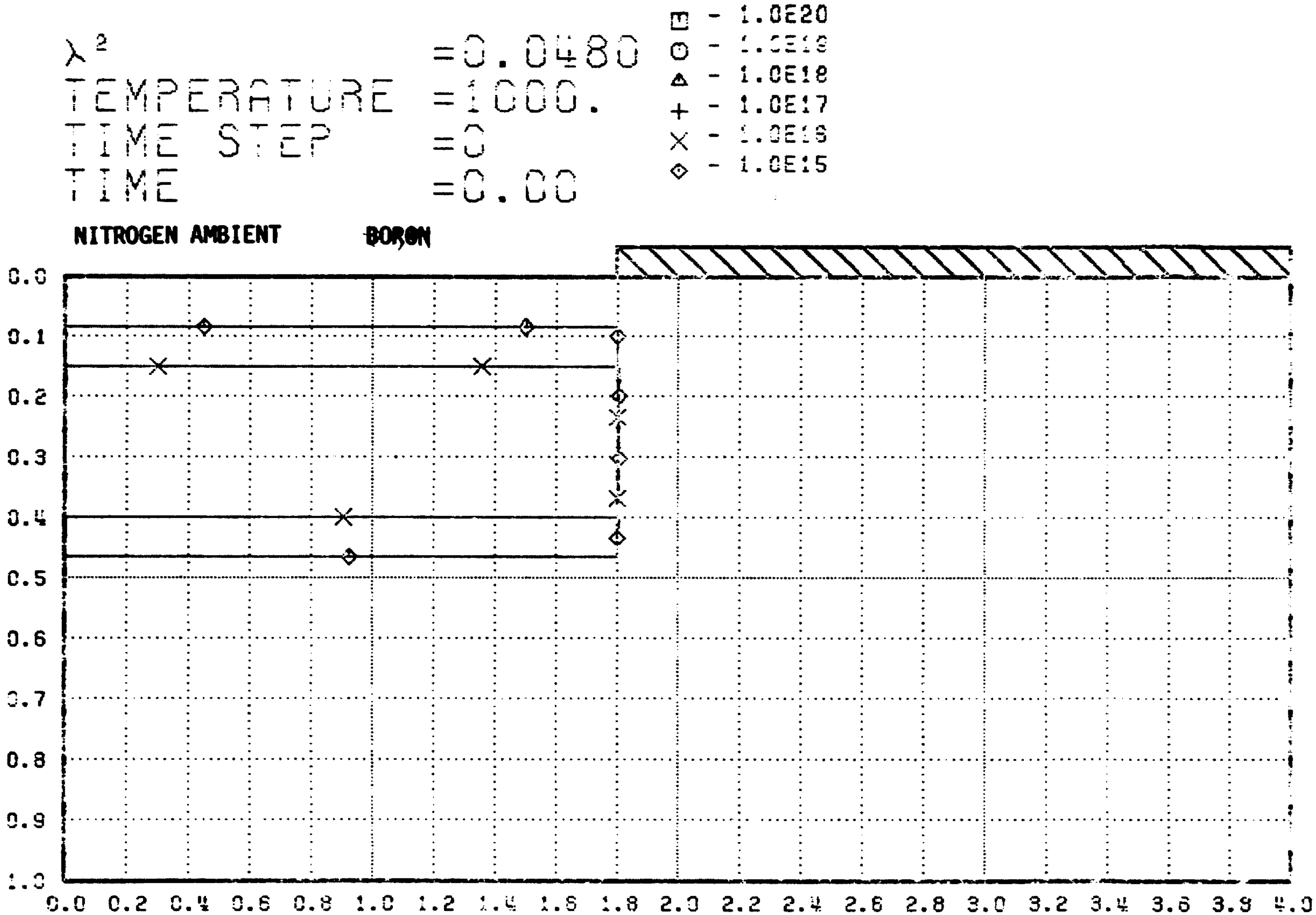
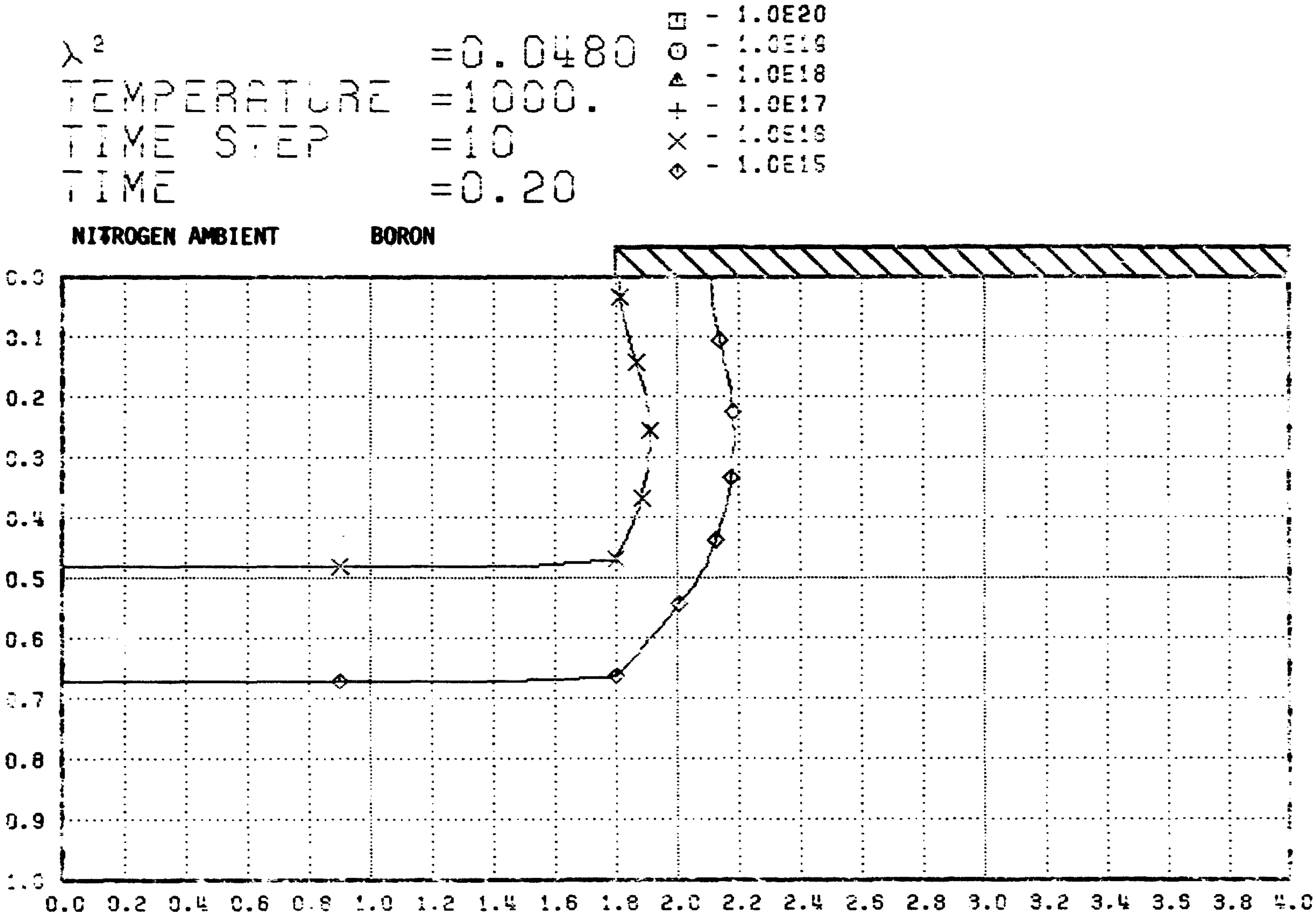
APPENDIX

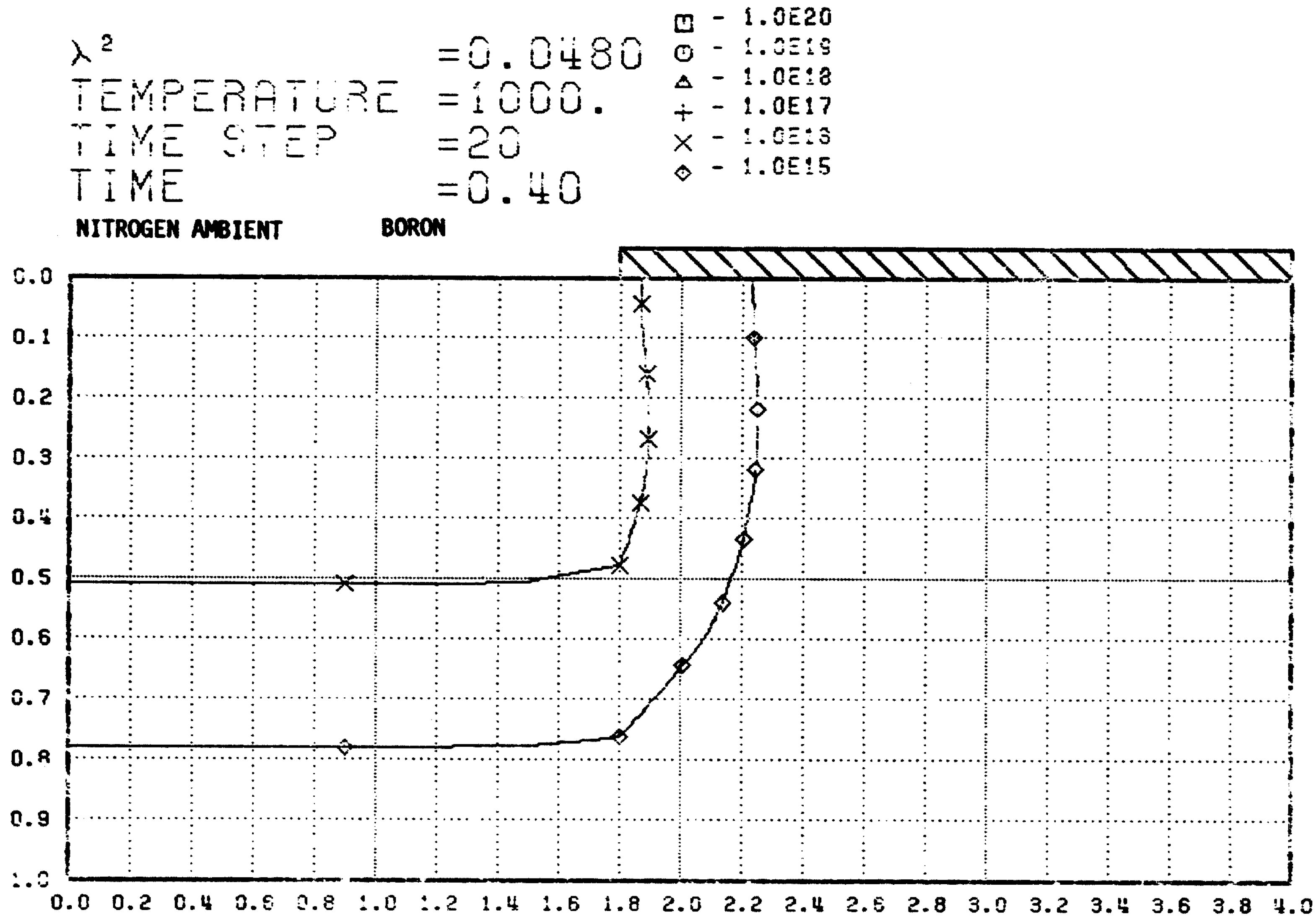
BORON DATA

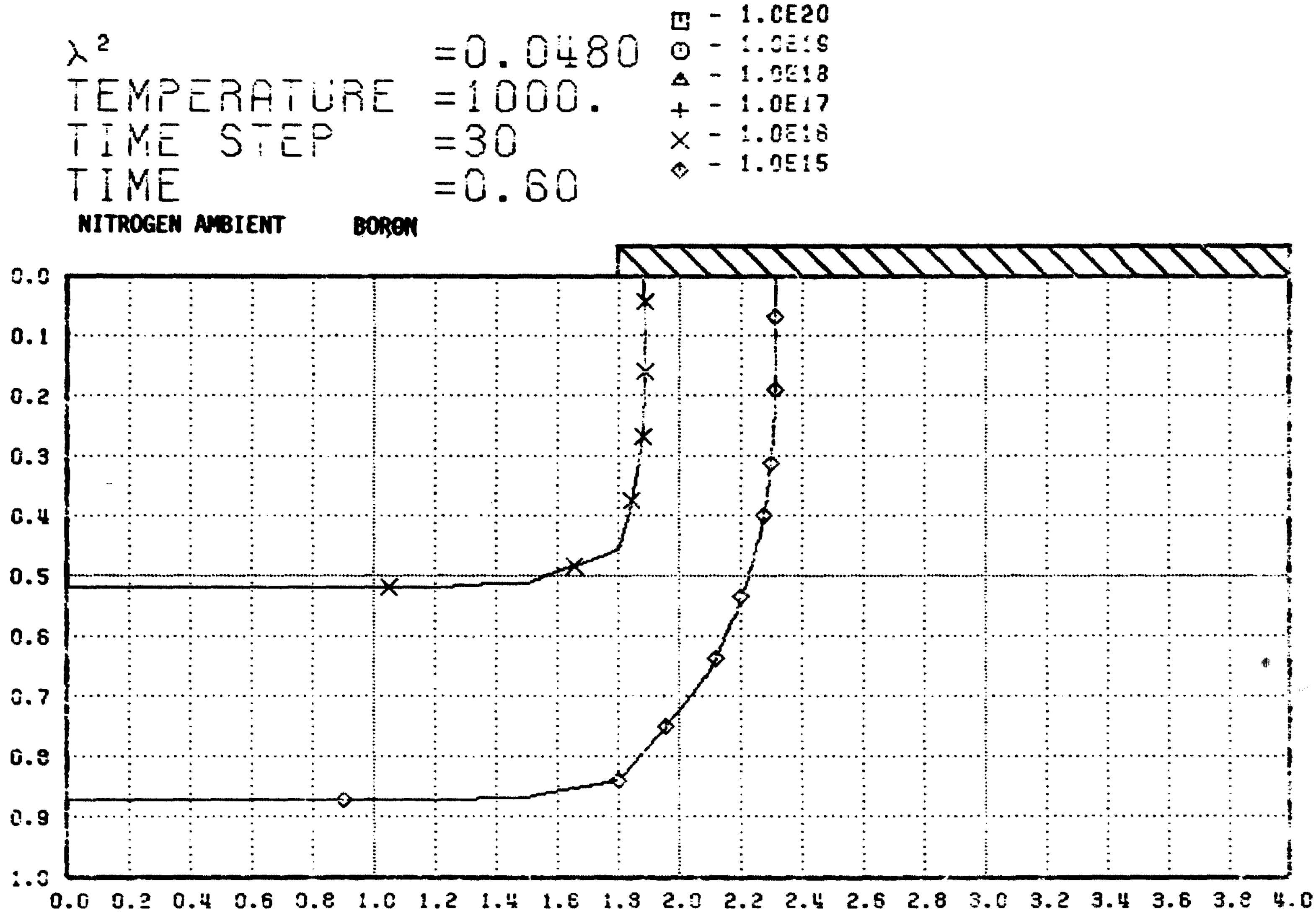


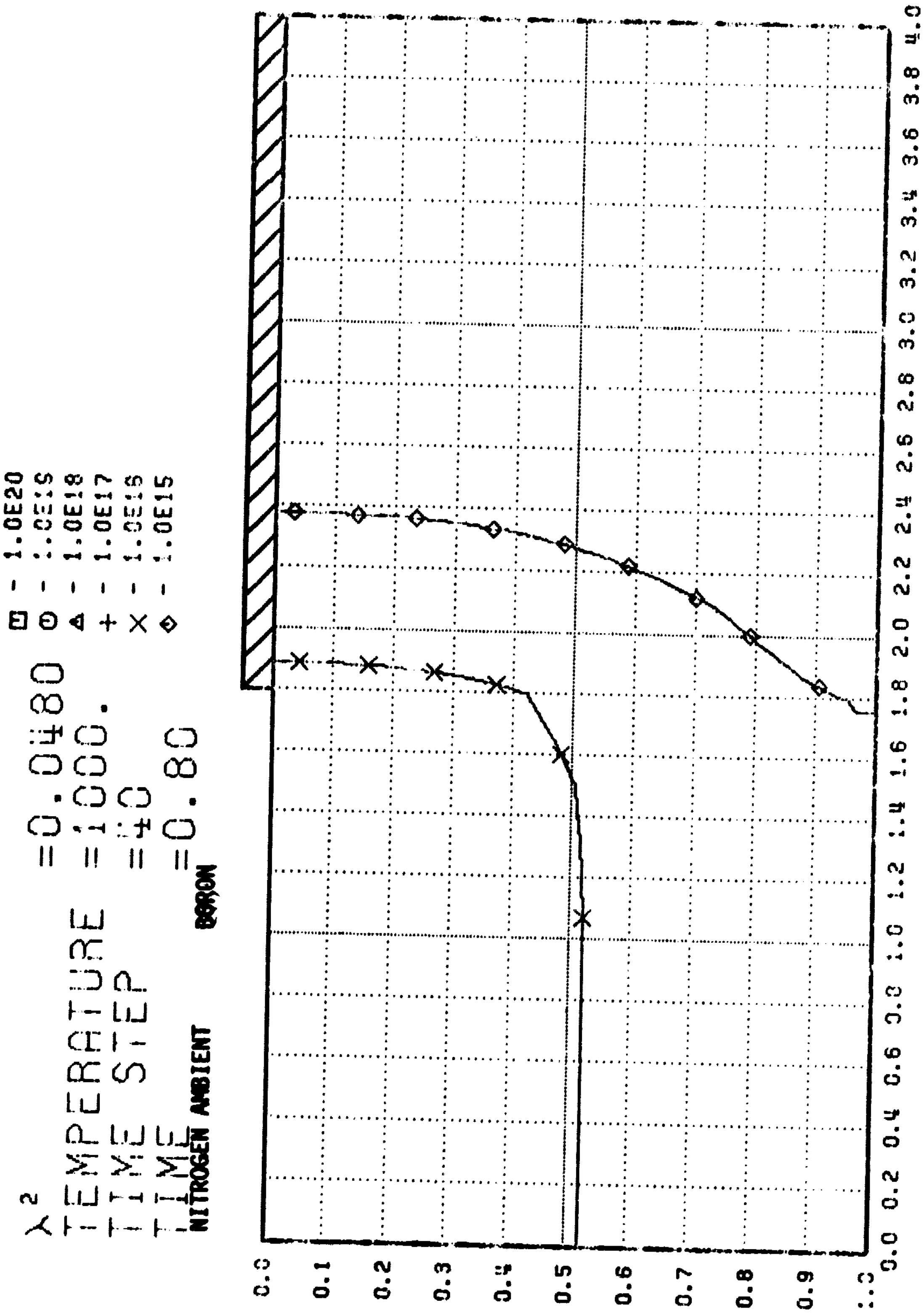
λ² =0.0480
TEMPERATURE =1000.
TIME STEP =0
TIME =0.00
□ - 1.0E20
○ - 1.0E19
△ - 1.0E18
+ - 1.0E17
× - 1.0E16
◇ - 1.0E15
NITROGEN AMBIENT
BORON
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0

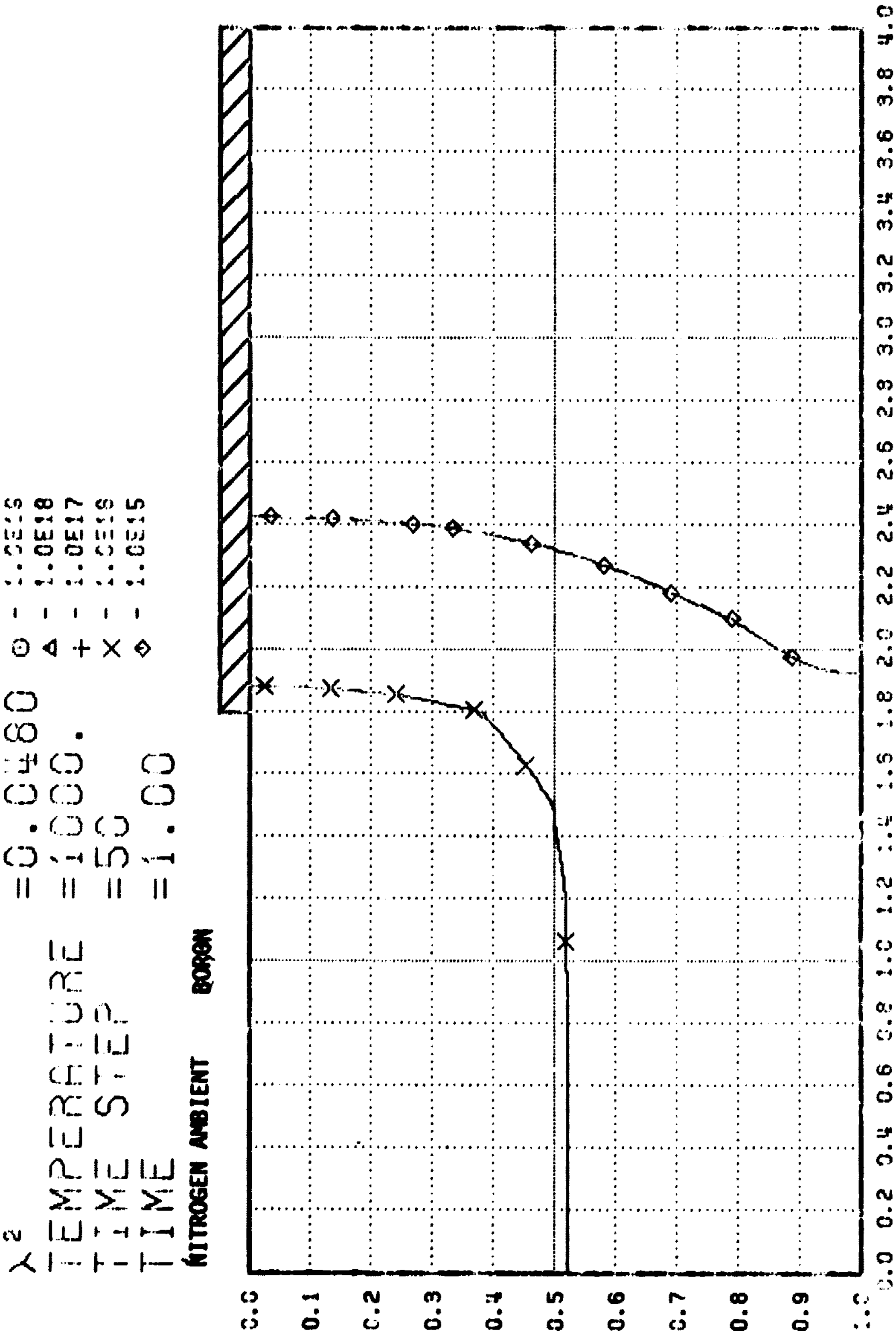

λ² =0.0480
TEMPERATURE =1000.
TIME STEP =10
TIME =0.20
⊞ - 1.0E20
⊙ - 1.0E19
△ - 1.0E18
+ - 1.0E17
× - 1.0E16
◇ - 1.0E15
NITROGEN AMBIENT
BORON
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0

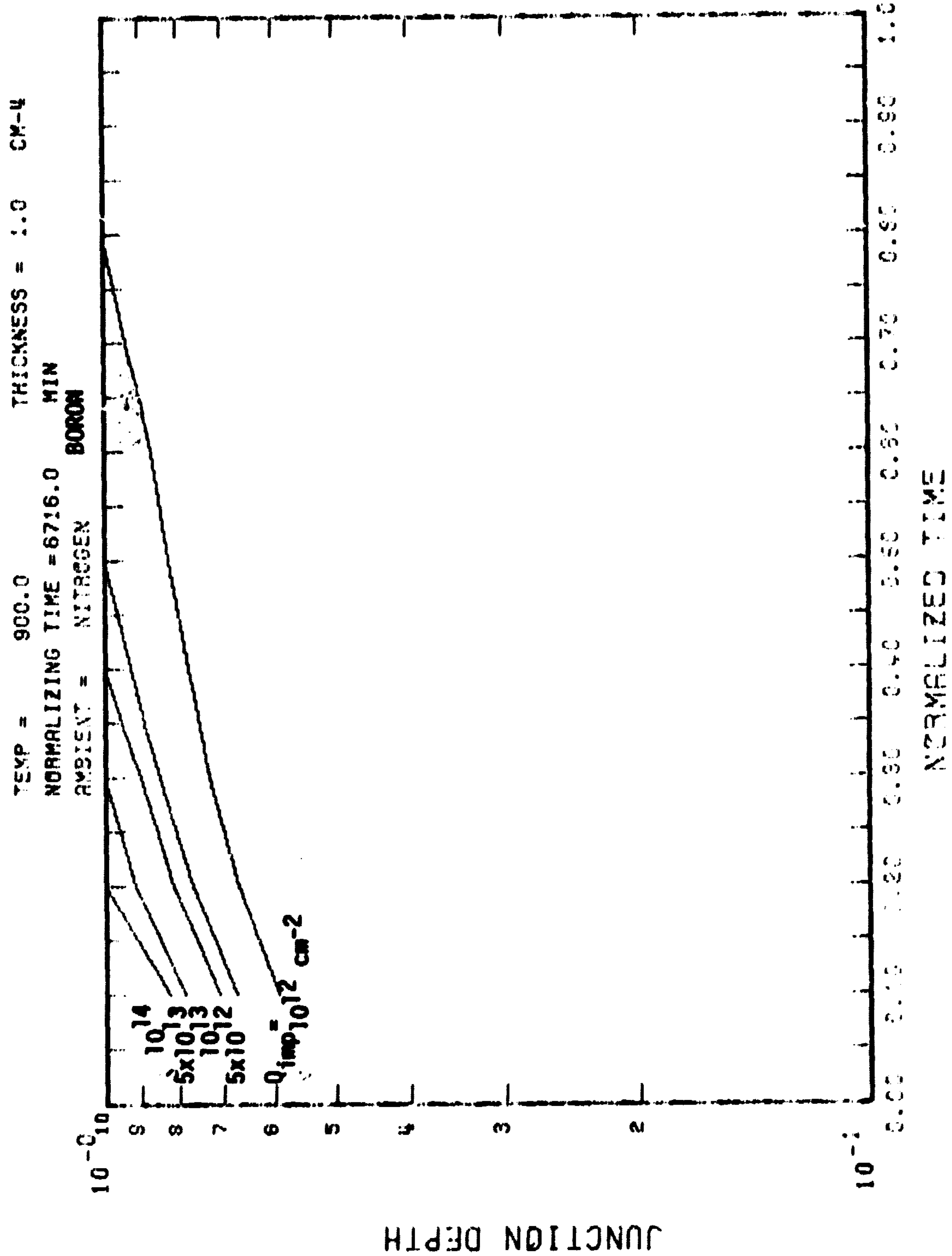
A 2


λ 2 =0.0480
TEMPERATURE =1000.
TIME STEP =20
TIME =0.40
NITROGEN AMBIENT
BORON
- 1.0E20
- 1.0E19
- 1.0E18
- 1.0E17
- 1.0E16
- 1.0E15
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0


λ 2 =0.0480
TEMPERATURE =1000.
TIME STEP =30
TIME =0.60
NITROGEN AMBIENT
BORON
1.0E20
1.0E19
1.0E18
1.0E17
1.0E16
1.0E15
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0


λ² =0.0480
TEMPERATURE =1000.
TIME STEP =40
TIME =0.80
NITROGEN AMBIENT
BORON
- 1.0E20
- 1.0E19
- 1.0E18
- 1.0E17
- 1.0E16
- 1.0E15
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0


X2 =0.0480
TEMPERATURE =1000.
TIME STEP =50
TIME =1.00
NITROGEN AMBIENT
BORON
⊞ - 1.0E20
⊙ - 1.0E19
△ - 1.0E18
+ - 1.0E17
× - 1.0E16
◇ - 1.0E15
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0


TEMP = 900.0
THICKNESS = 1.0
NORMALIZING TIME = 6716.0
MIN
AMBIENT = NITROGEN
BORON
Q imp = 10^12 cm^-2
5x10^12
10^13
5x10^13
10^14
NORMALIZED TIME
JUNCTION DEPTH

ORIGINAL PAGE IS
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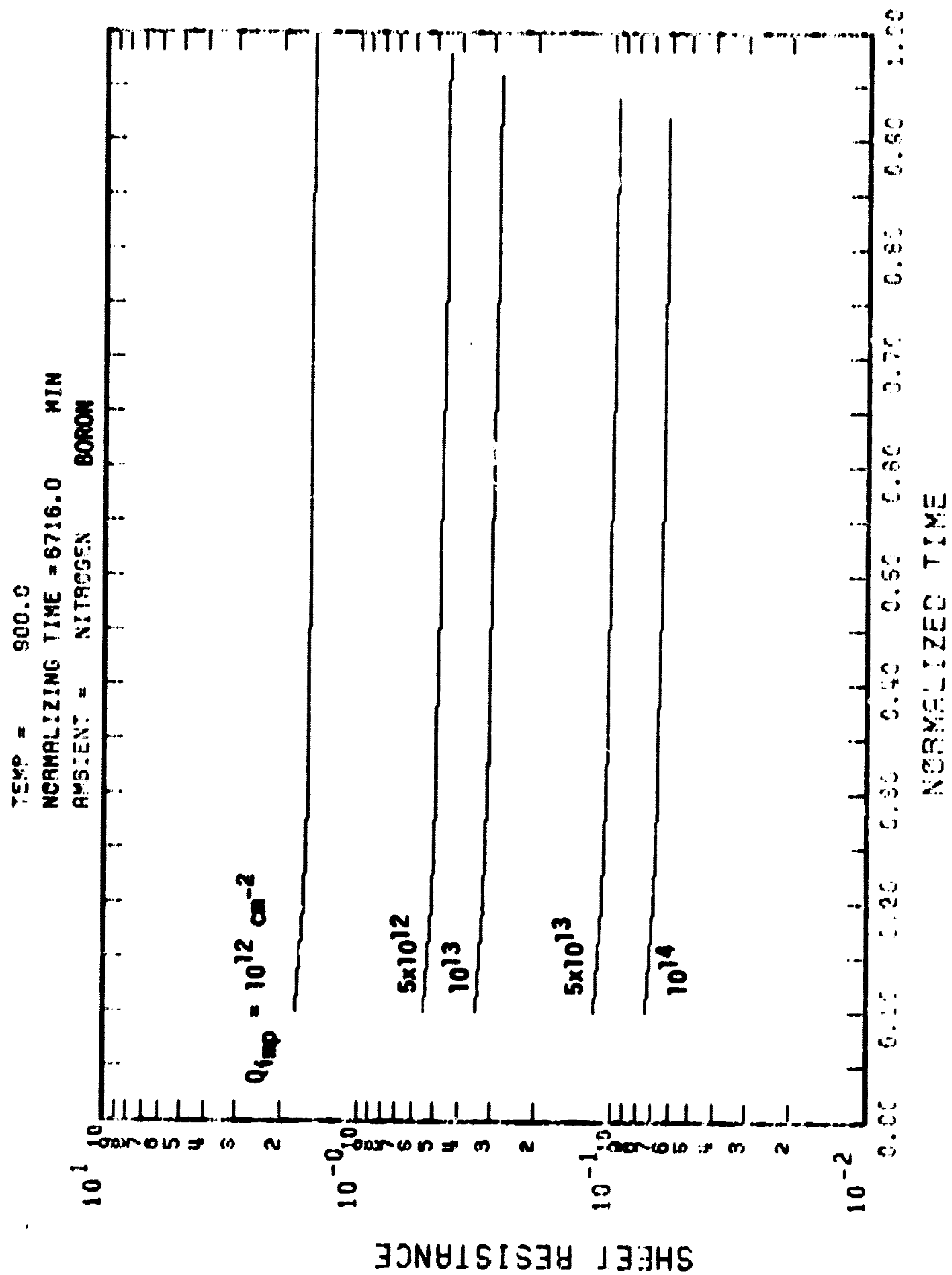

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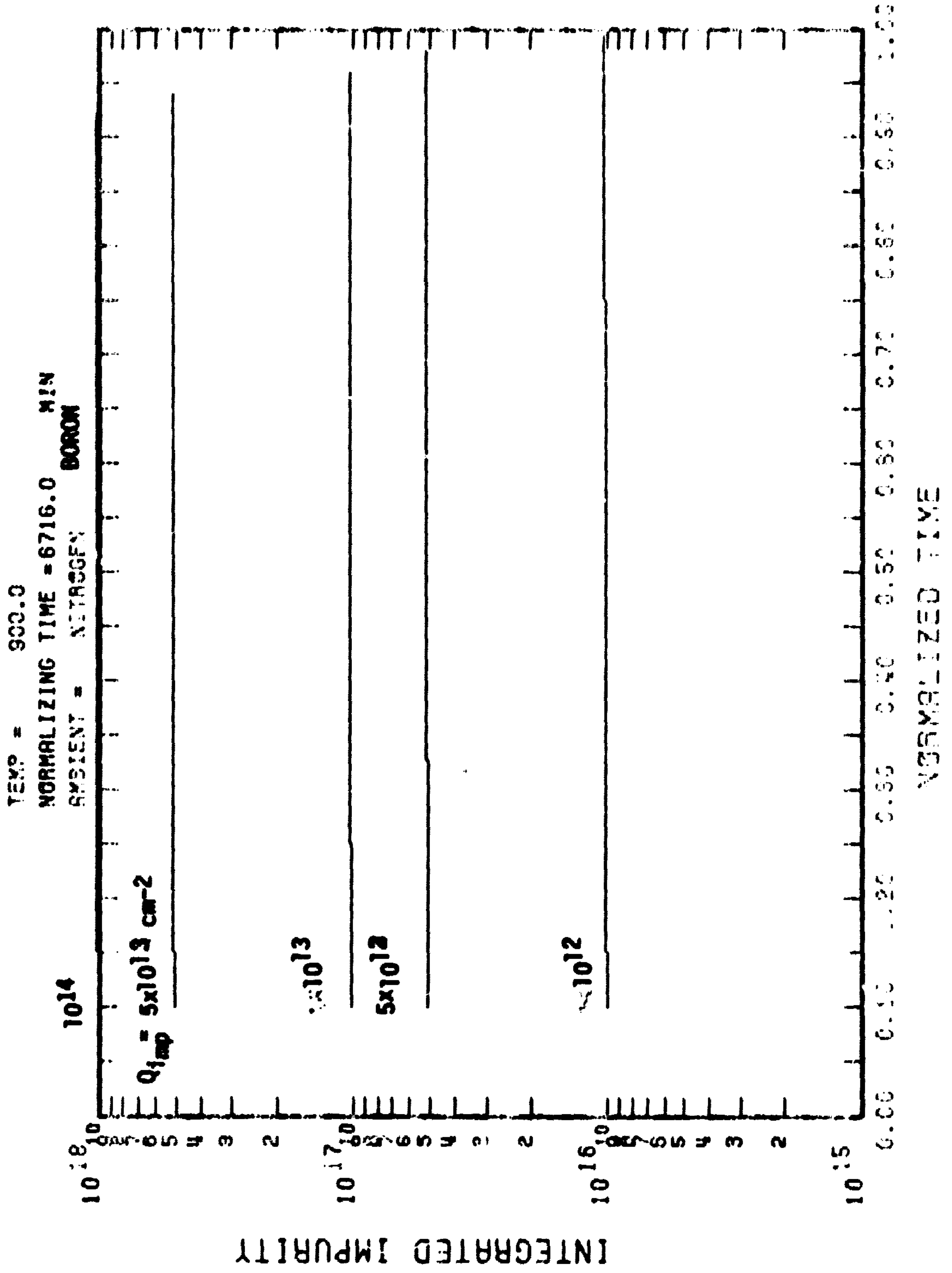
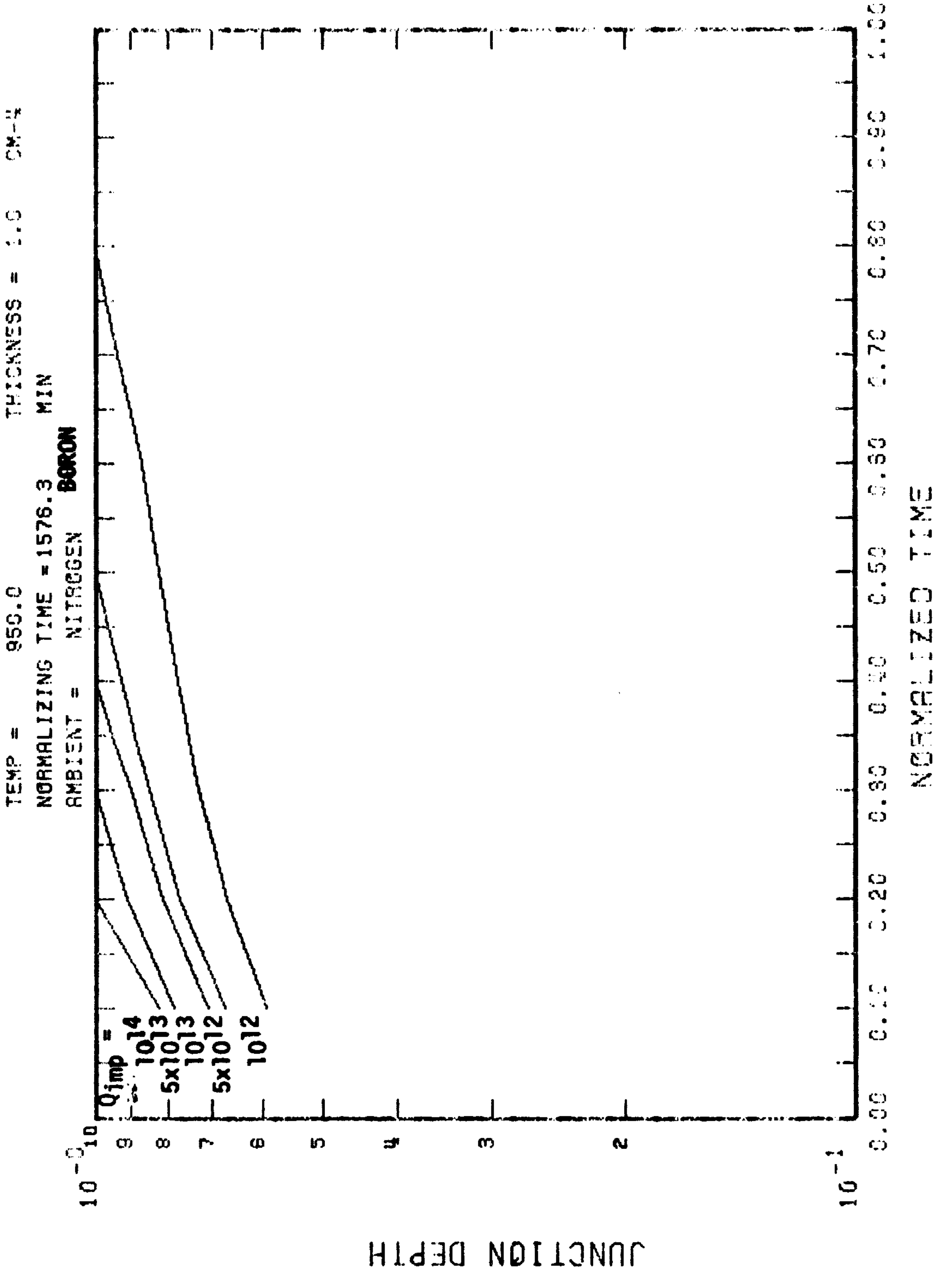
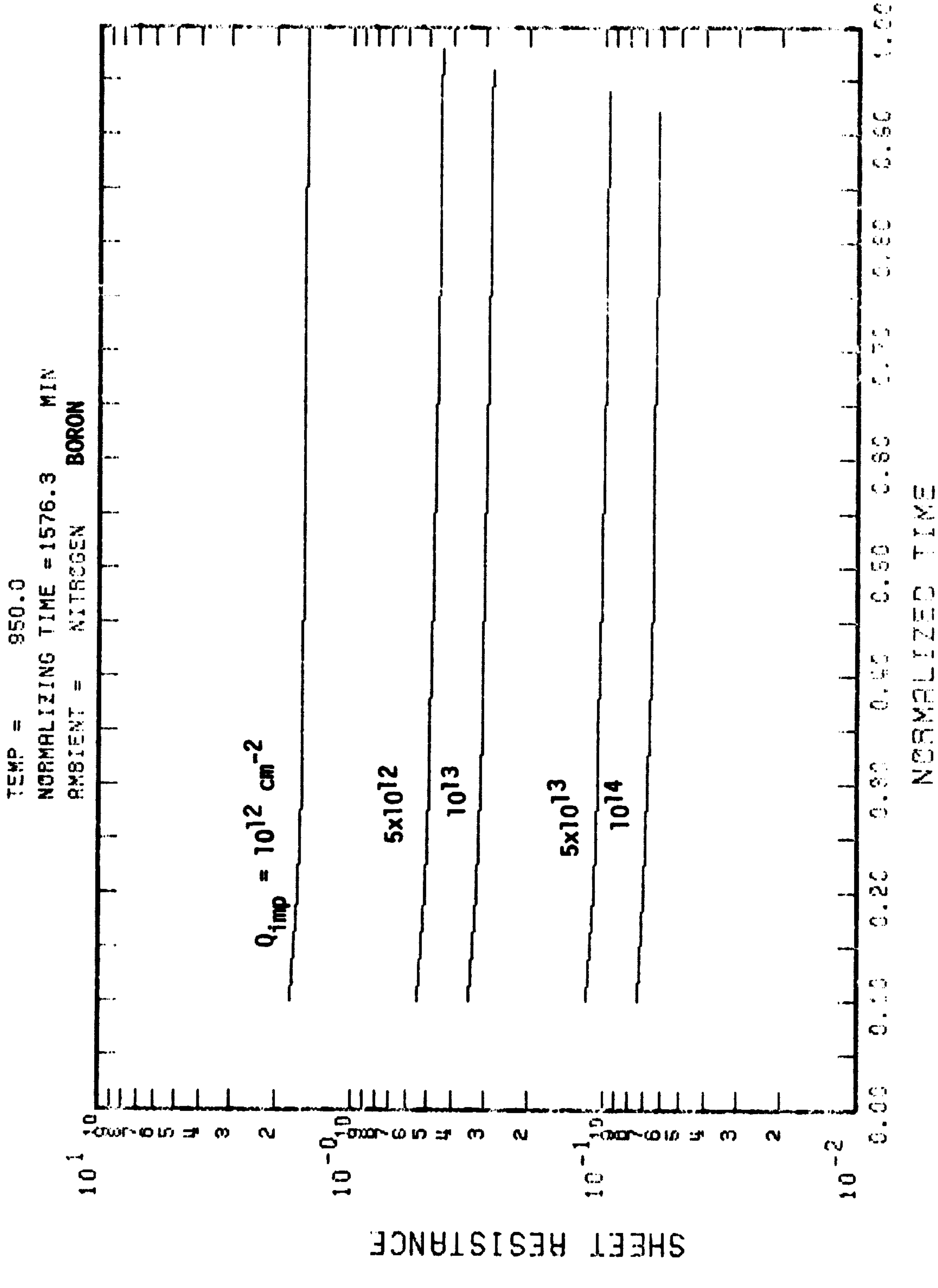
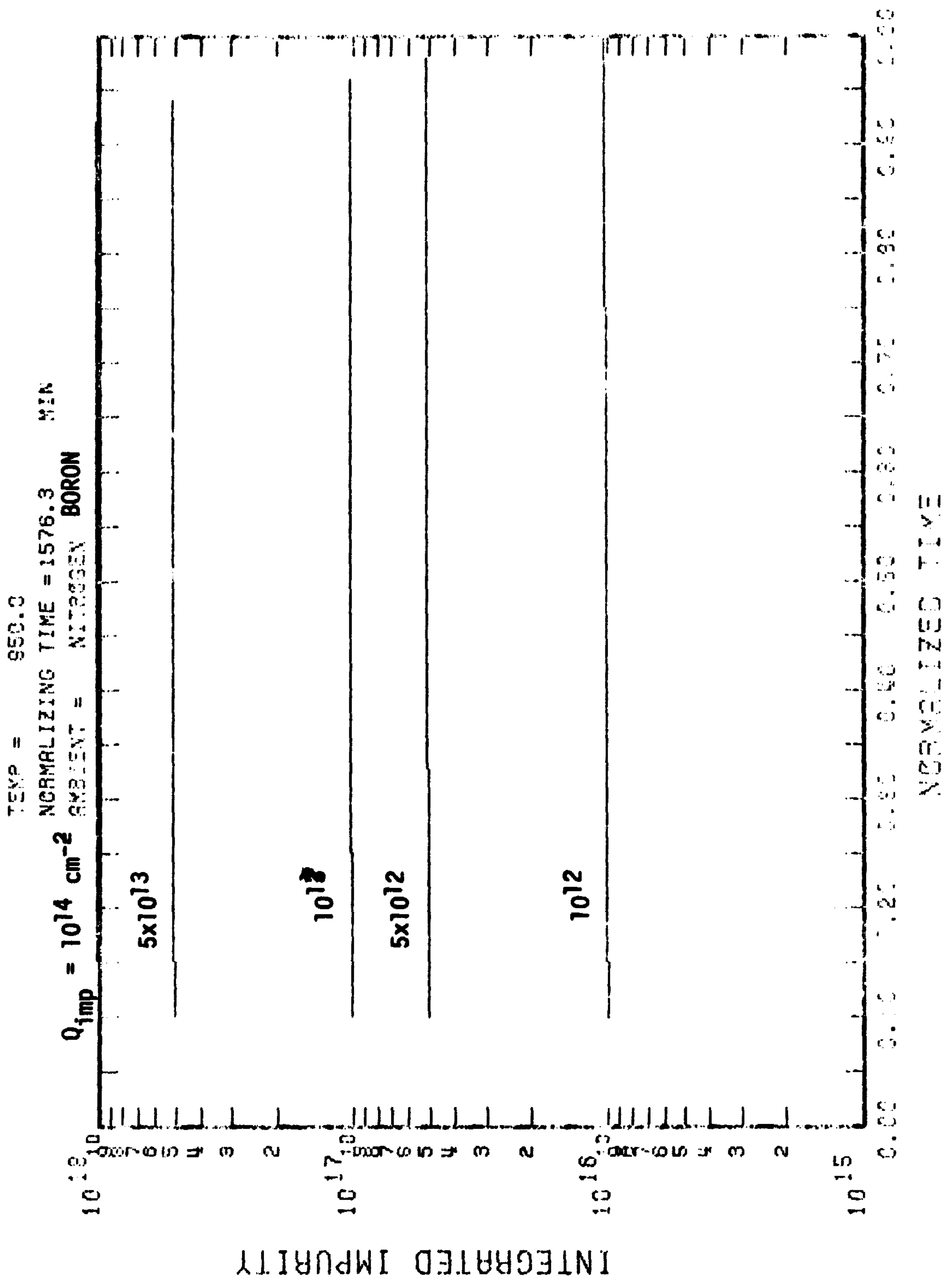
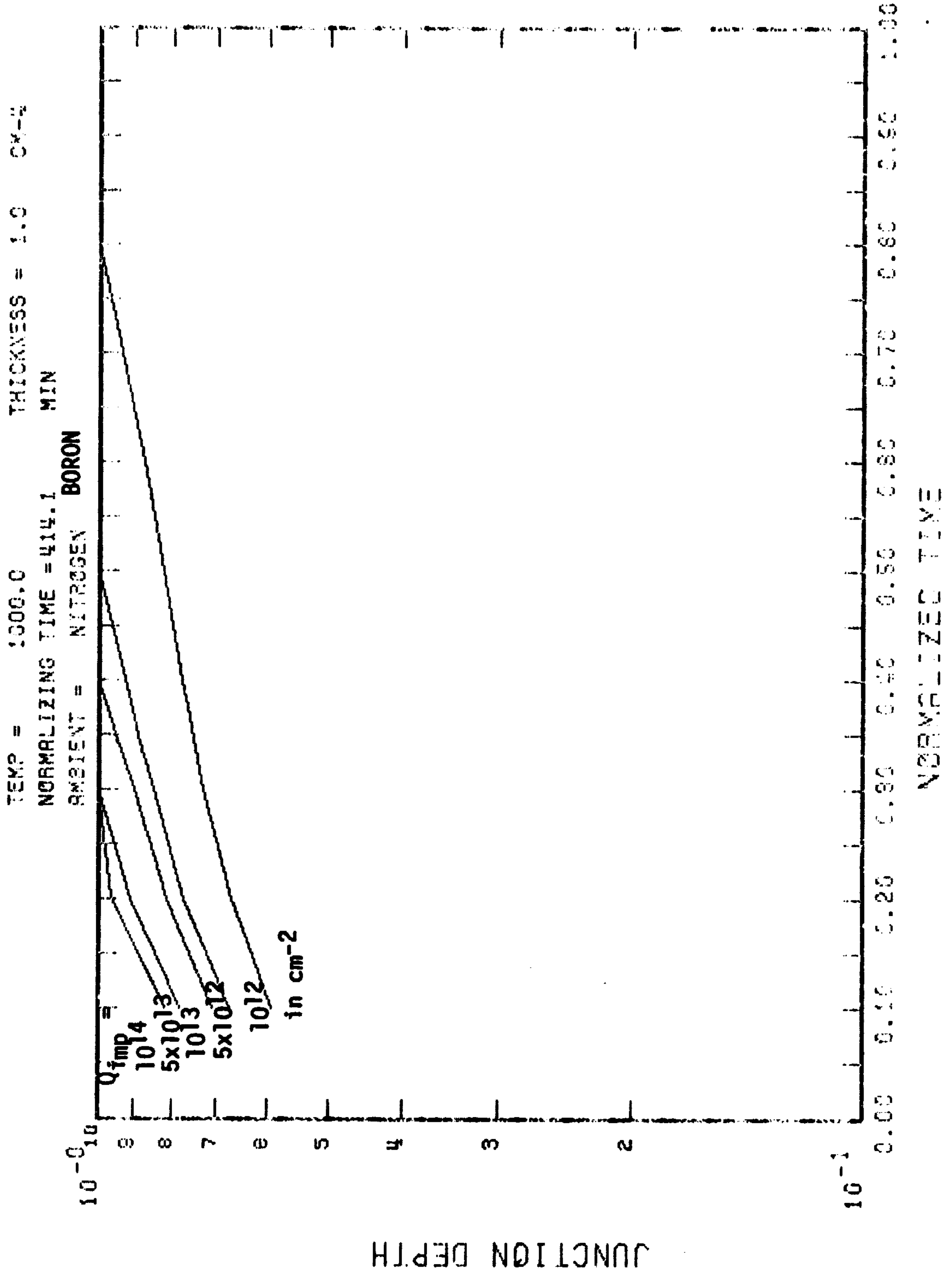
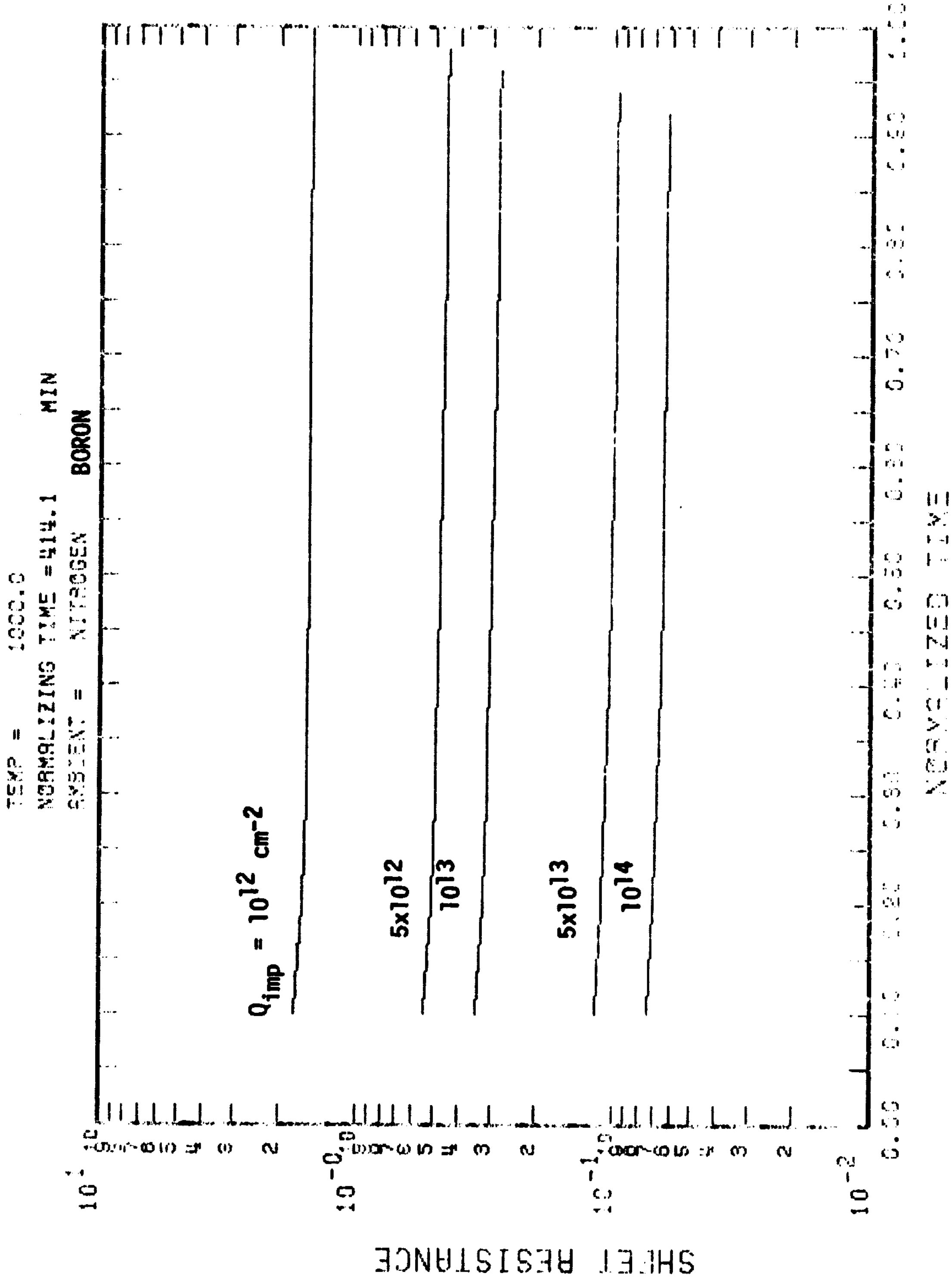



TEMP = 950.0
THICKNESS = 1.0
NORMALIZING TIME =1576.3 MIN
AMBIENT = NITROGEN
BORON
Q_imp =
10^14
5x10^13
10^13
5x10^12
10^12
NORMALIZED TIME
JUNCTION DEPTH
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
10^-0
10^-1


TEMP = 950.0
NORMALIZING TIME =1576.3 MIN
AMBIENT = NITROGEN
BORON
Q_imp = 10^12 cm^-2
5x10^12
10^13
5x10^13
10^14
SHEET RESISTANCE
NORMALIZED TIME


TEMP = 950.0
NORMALIZING TIME =1576.3 MIN
AMBIENT = NITROGEN BORON
$Q_{imp} = 10^{14}$ cm^{-2}
5x10^{13}
10^{13}
5x10^{12}
10^{12}
NORMALIZED TIME
INTEGRATED IMPURITY


TEMP = 1000.0
THICKNESS = 1.0
NORMALIZING TIME = 414.1 MIN
AMBIENT = NITROGEN
BORON
Q_{fmp} =
10^{14}
$5x10^{13}$
10^{13}
$5x10^{12}$
10^{12}
in cm^{-2}
JUNCTION DEPTH
NORMALIZED TIME
10^{-1}
2
3
4
5
6
7
8
9
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


TEMP = 1000.0
NORMALIZING TIME = 414.1 MIN
AMBIENT = NITROGEN
BORON
Q_imp = 10^12 cm^-2
5x10^12
10^13
5x10^13
10^14
SHEET RESISTANCE
NORMALIZED TIME

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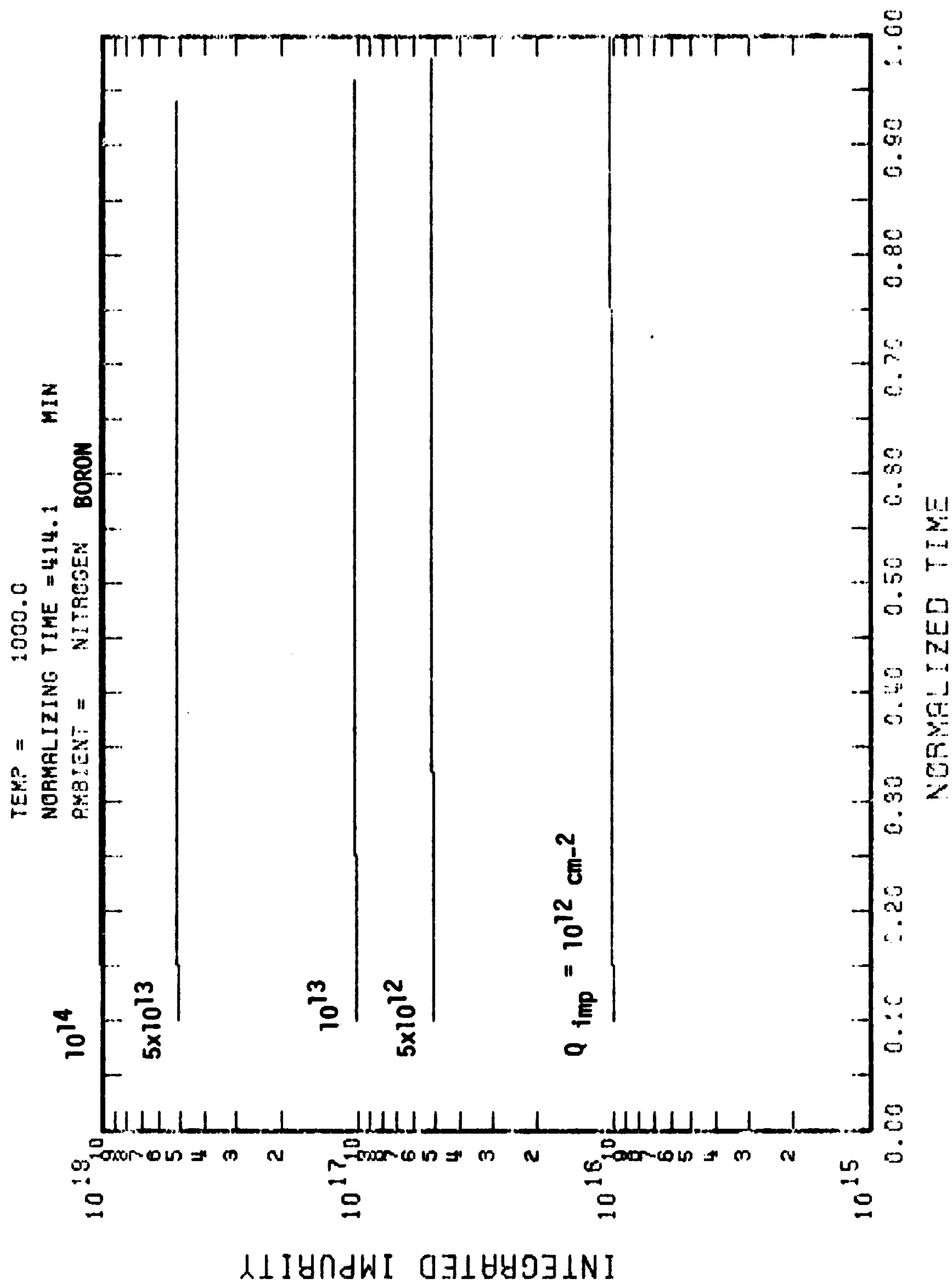
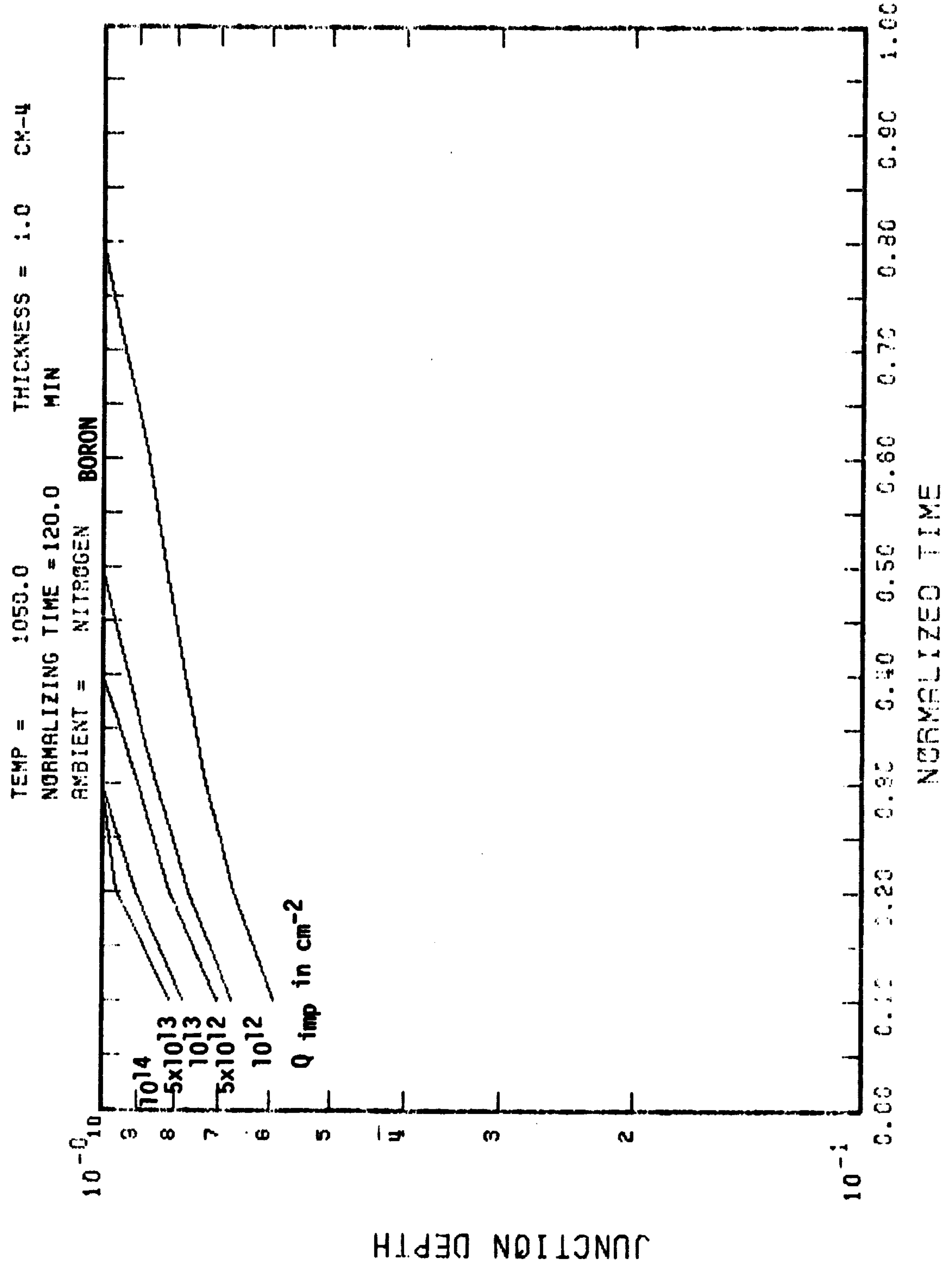
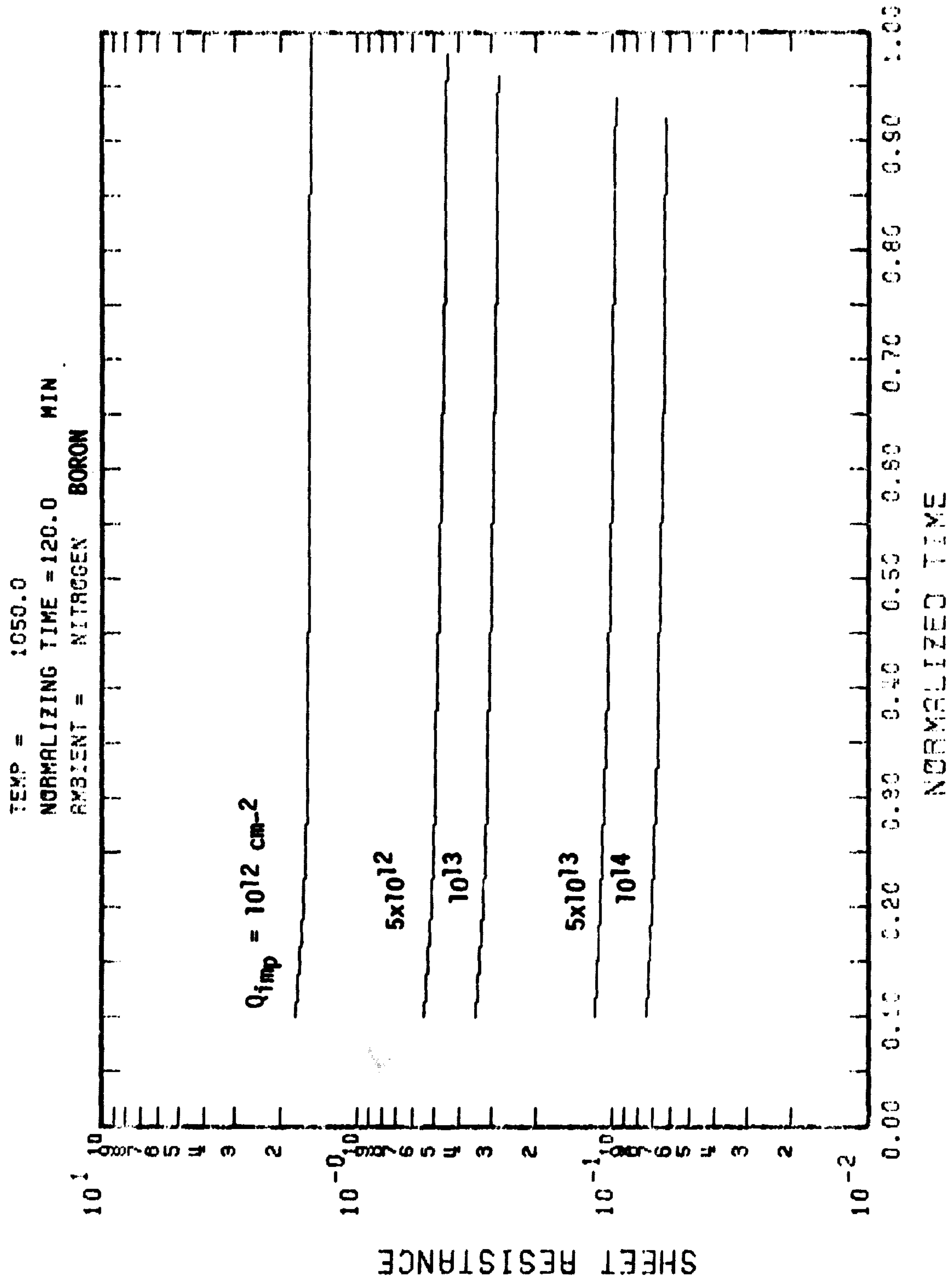



TEMP = 1050.0
THICKNESS = 1.0 CM-4
NORMALIZING TIME = 120.0 MIN
AMBIENT = NITROGEN
BORON
10^14
5x10^13
10^13
5x10^12
10^12
Q imp in cm^-2
NORMALIZED TIME
JUNCTION DEPTH
10^-0
10^-1
0.00
0.20
0.50
0.60
0.80
0.90
1.00


TEMP = 1050.0
NORMALIZING TIME =120.0 MIN
AMBIENT = NITROGEN
BORON
Q_imp = 10^12 cm^-2
5x10^12
10^13
5x10^13
10^14
SHEET RESISTANCE
NORMALIZED TIME

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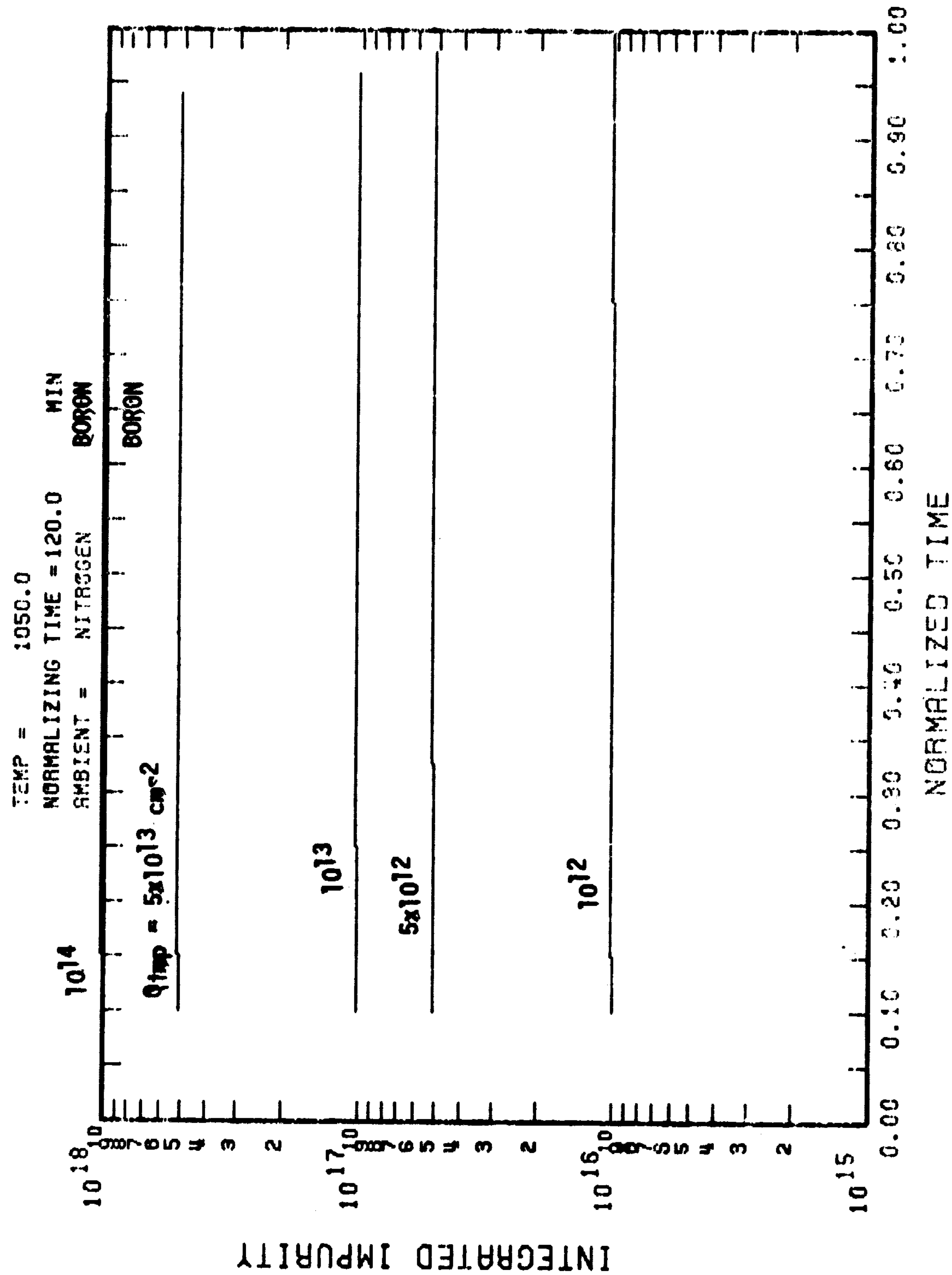
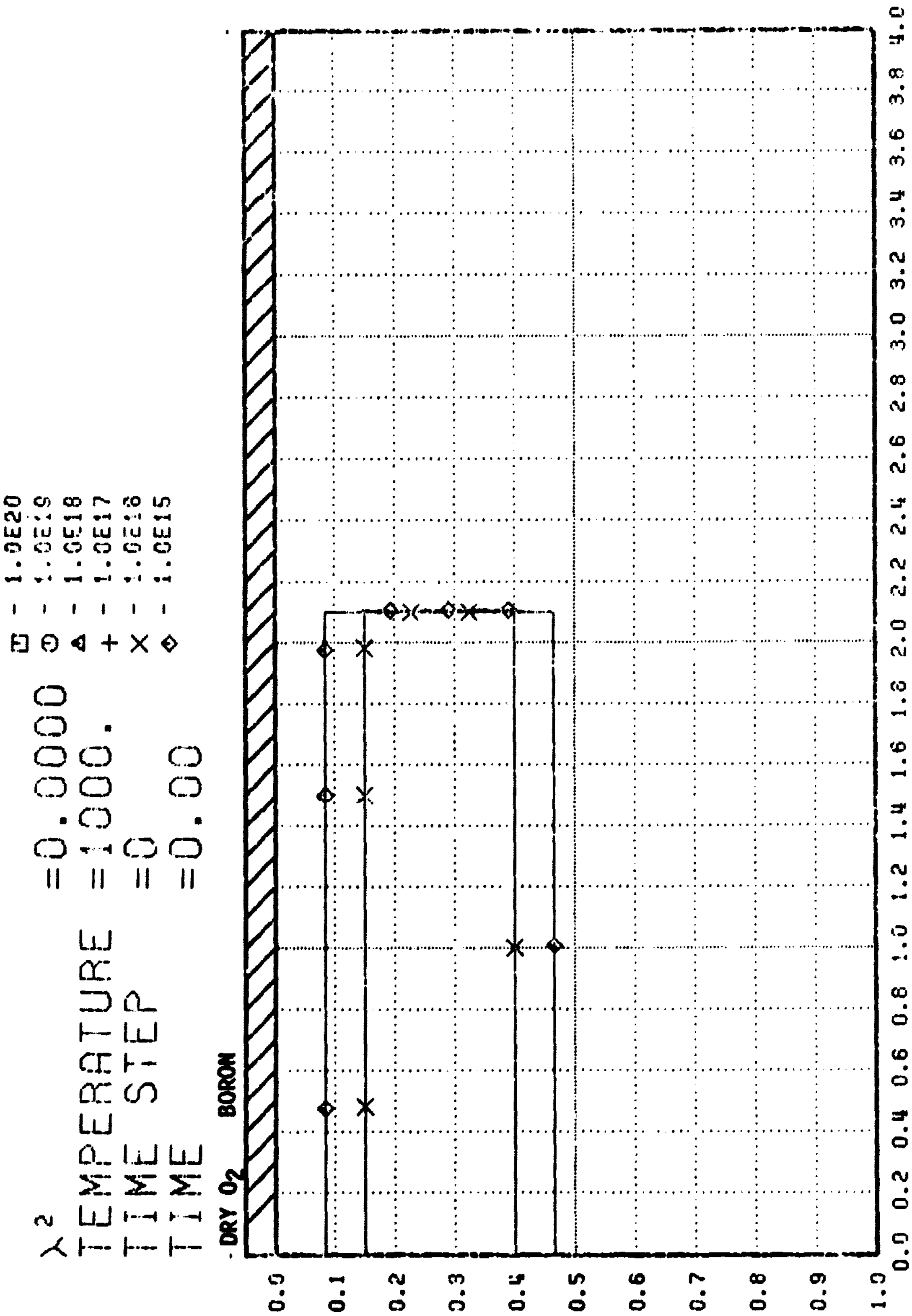
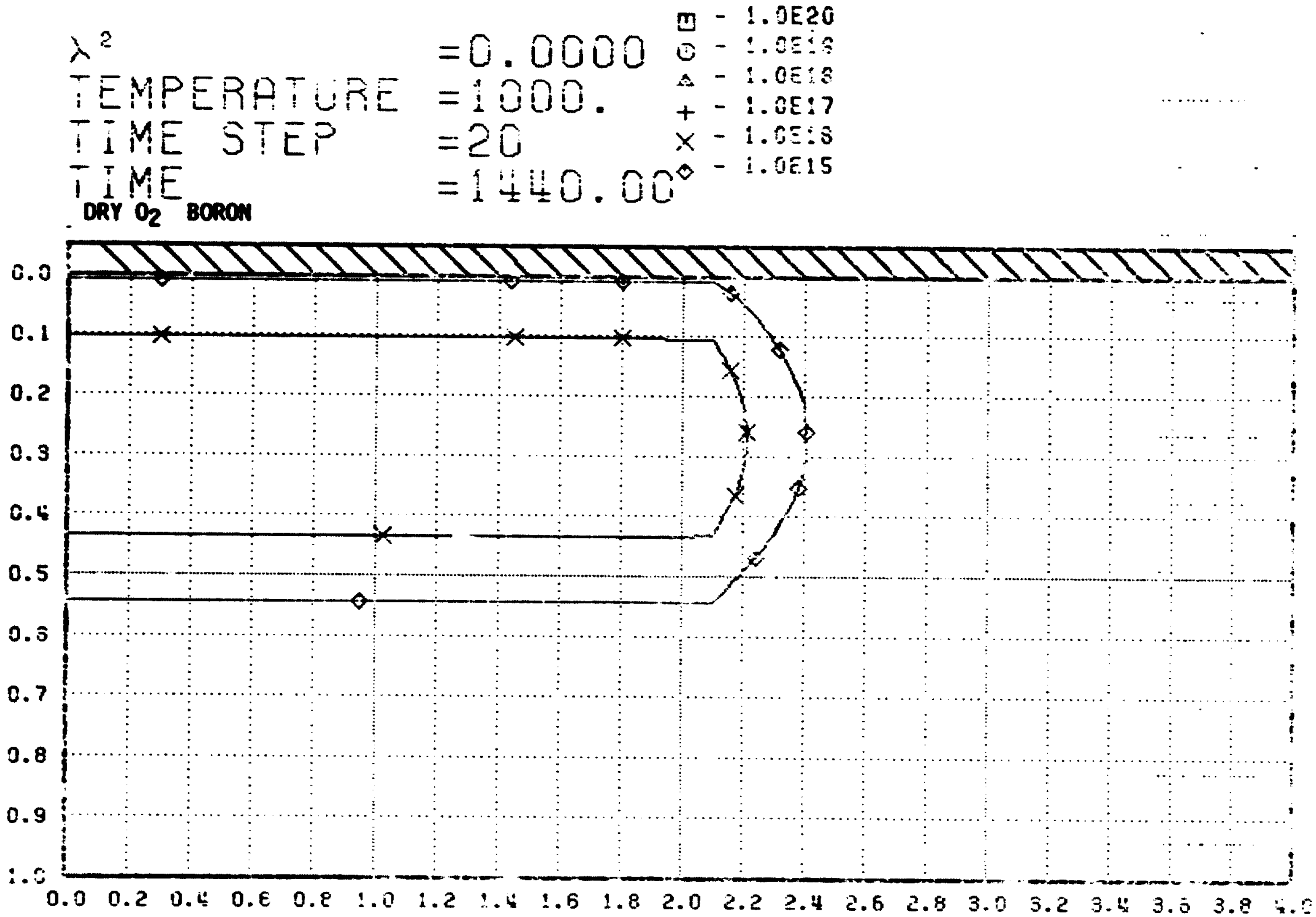




λ² =0.0000
TEMPERATURE =1000.
TIME STEP =0
TIME =0.00
□ - 1.0E20
⊖ - 1.0E19
△ - 1.0E18
+ - 1.0E17
× - 1.0E16
◇ - 1.0E15
DRY O2
BORON
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0



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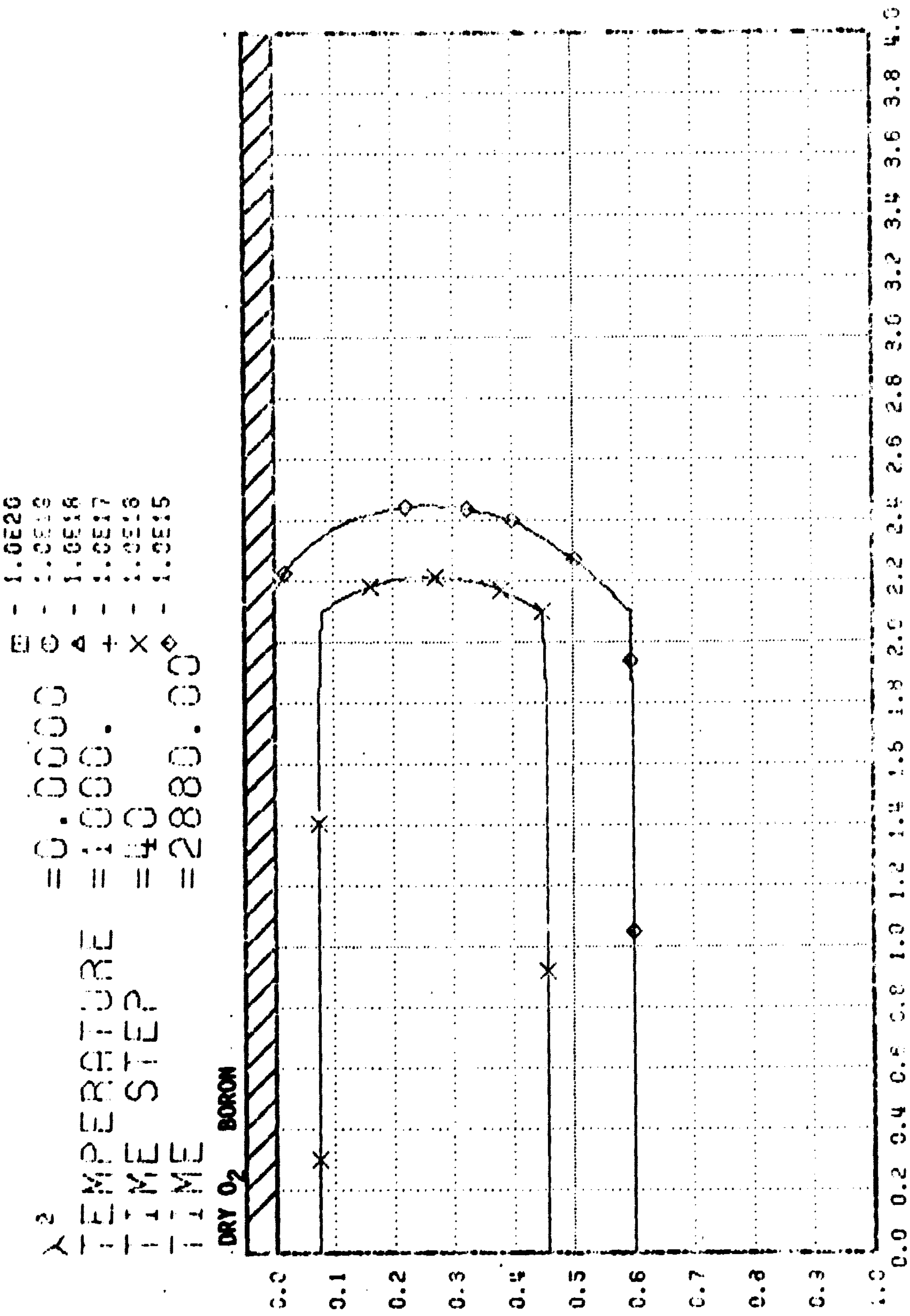
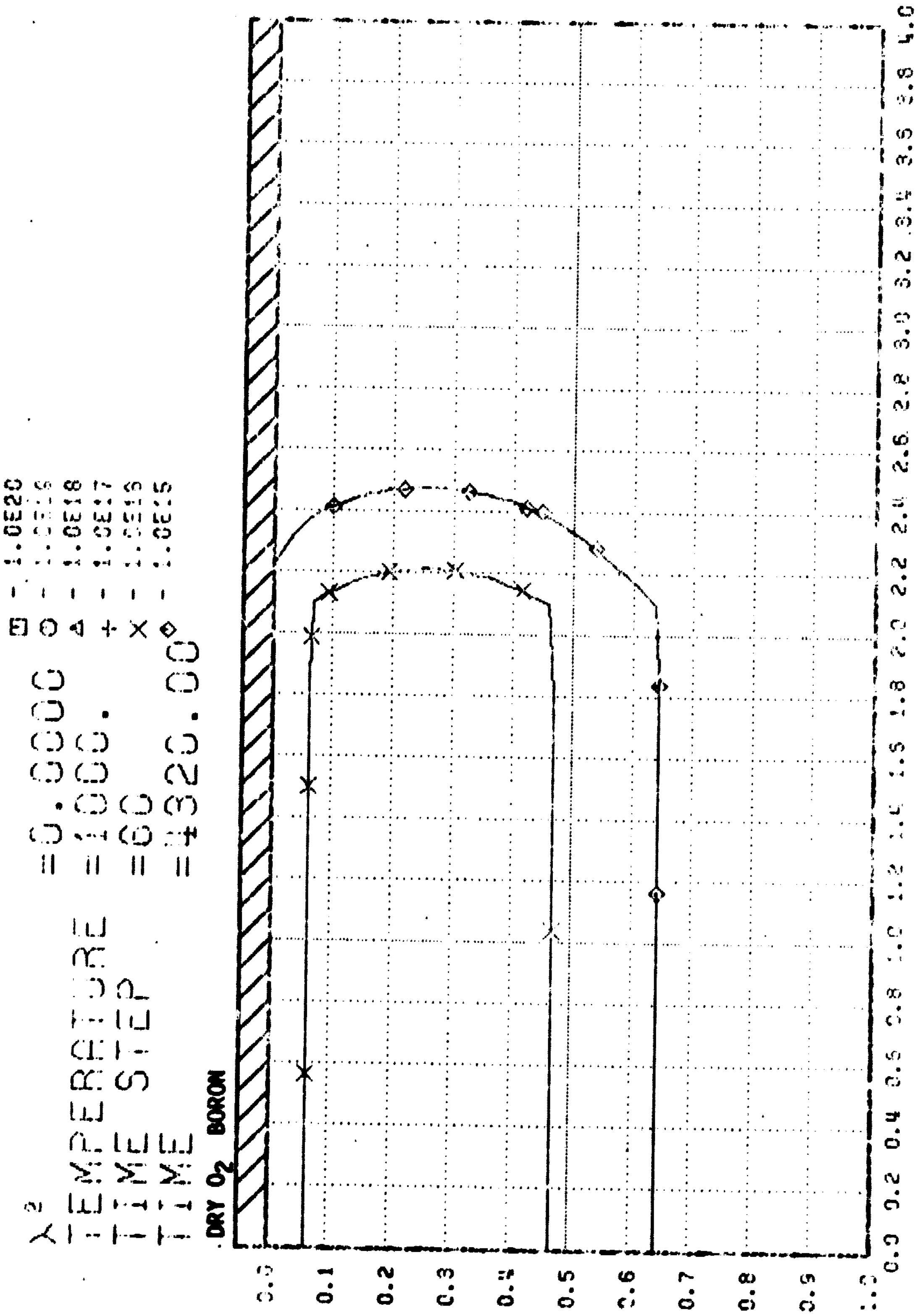
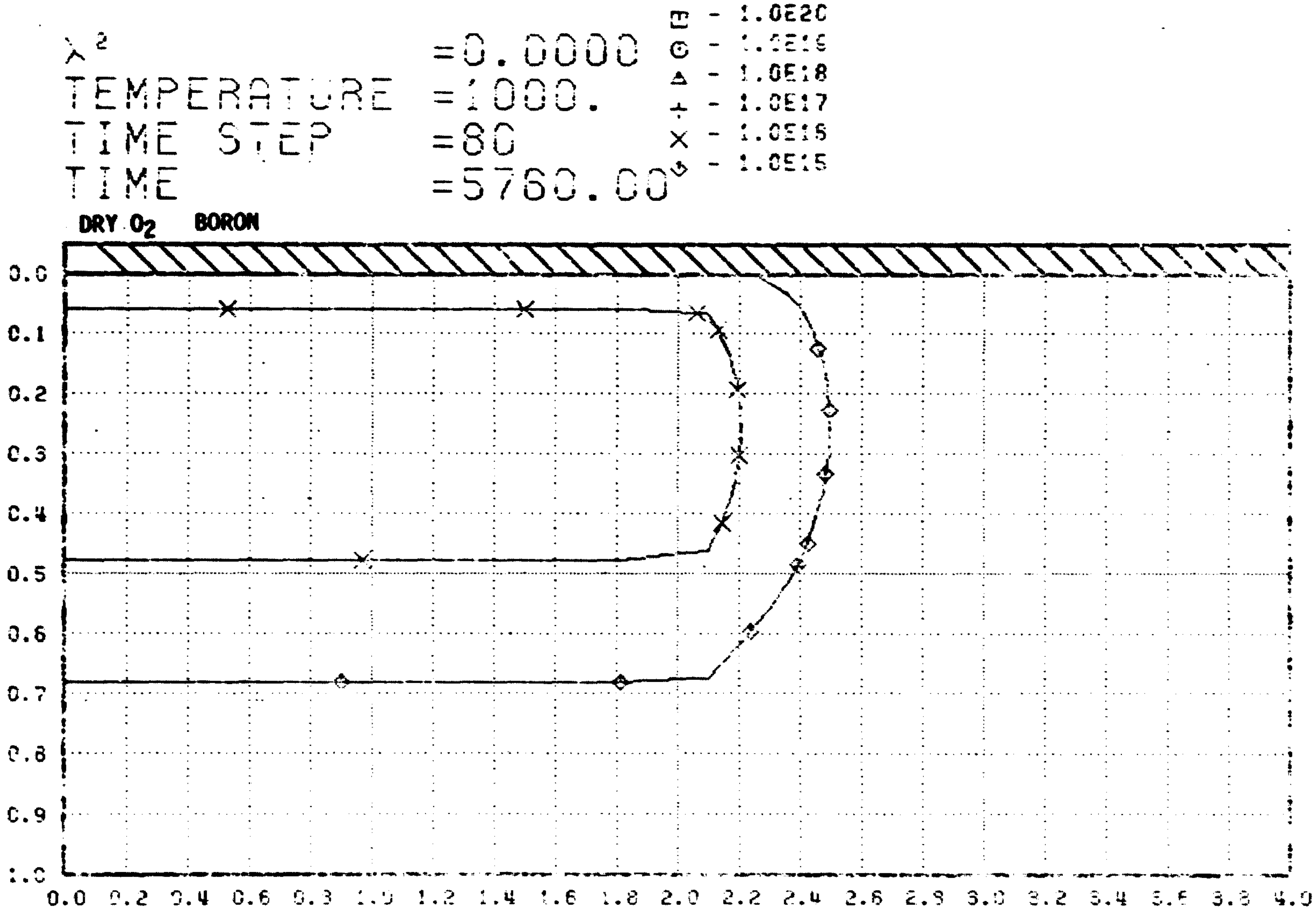
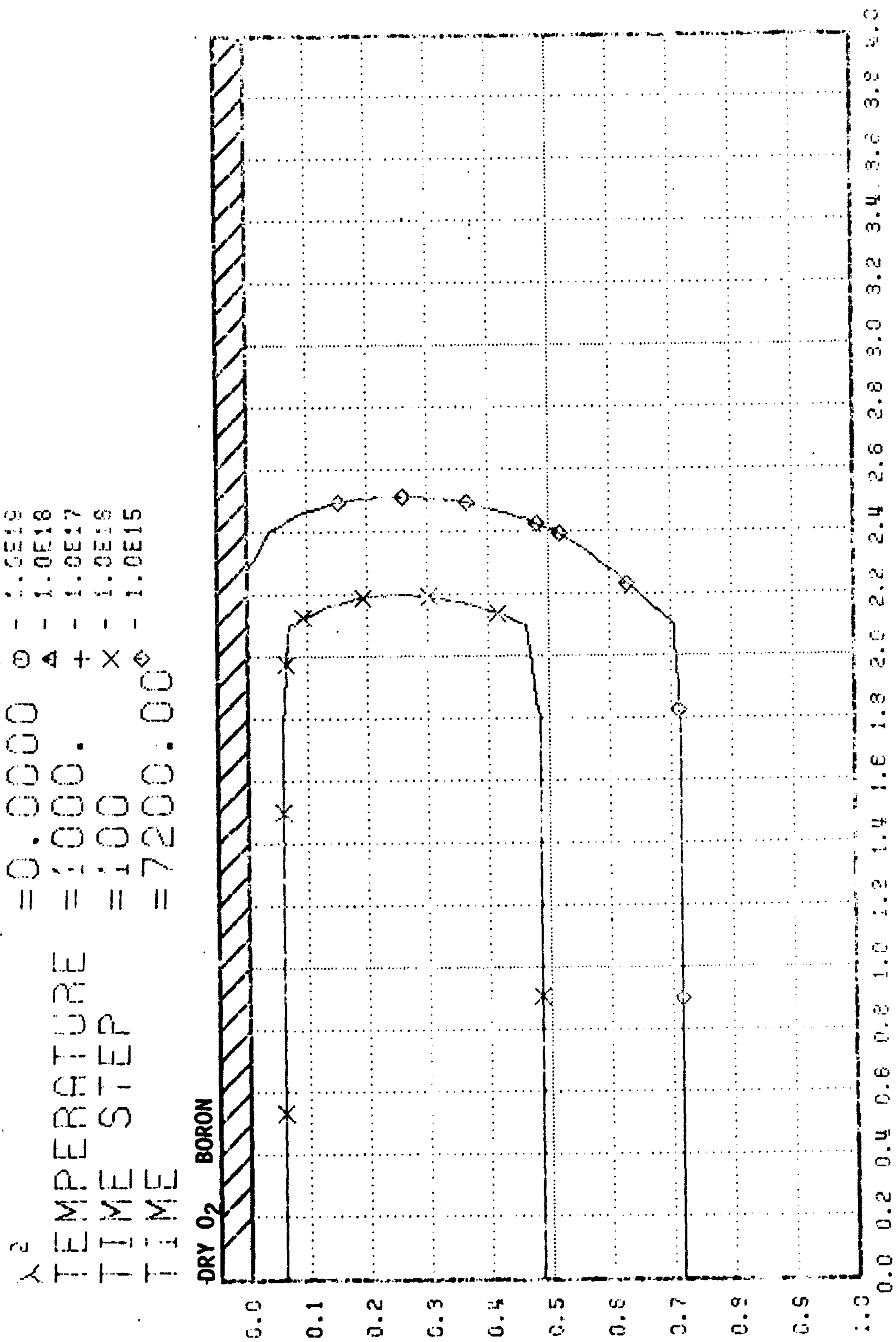
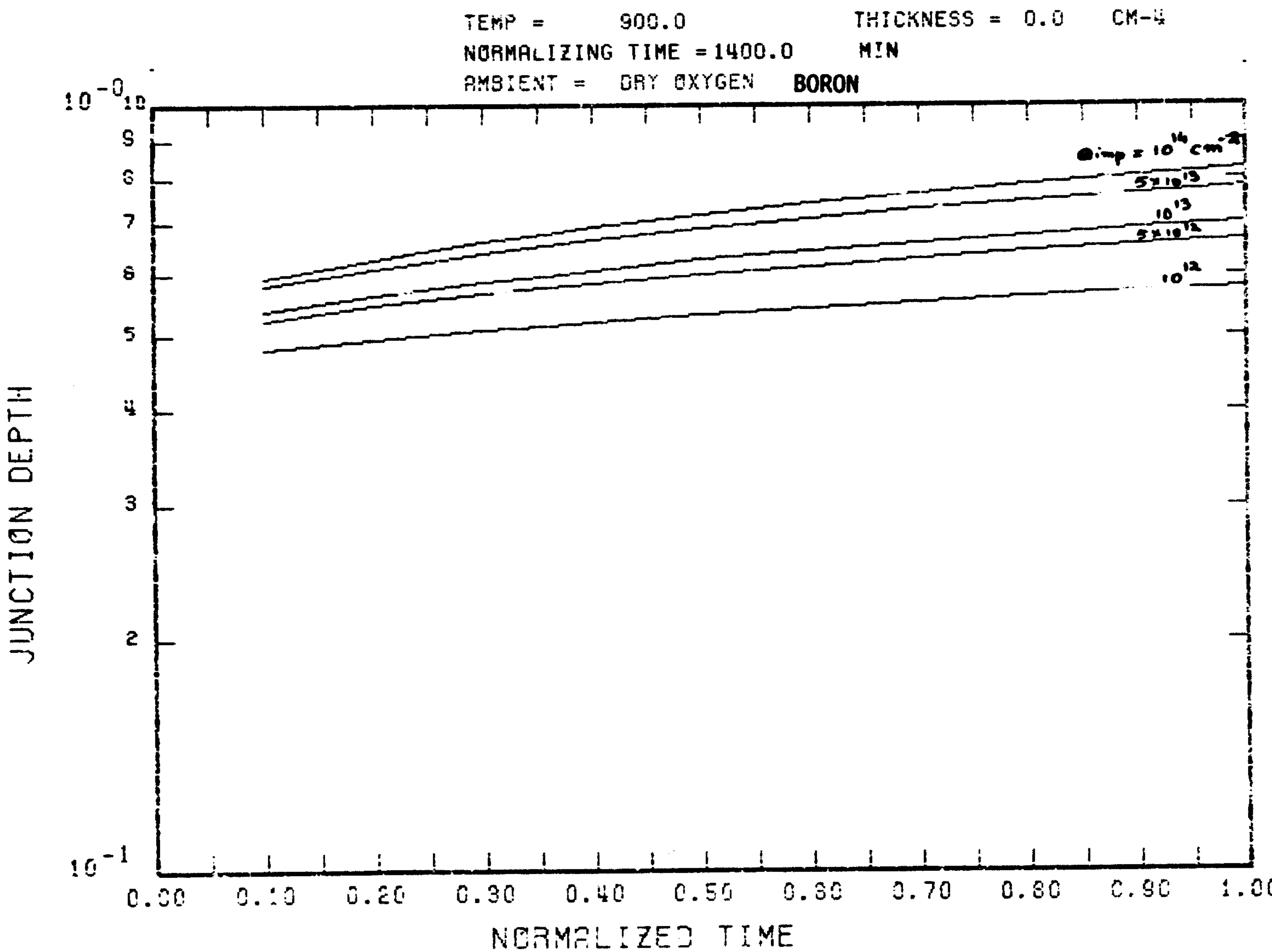

DRY O_2
BORON
TIME =2880.00
1.0E20
1.0E15

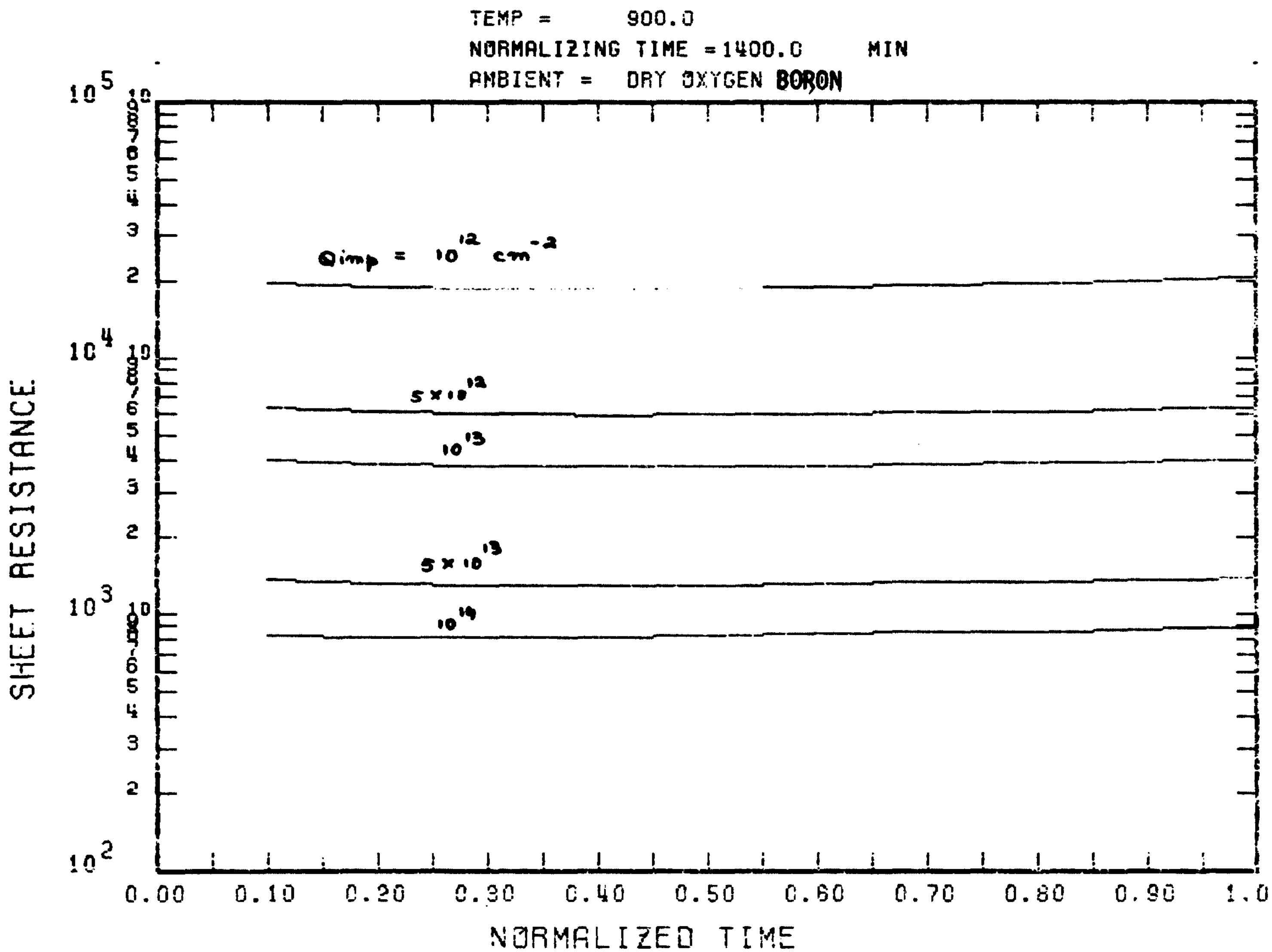

X² =0.0000
TEMPERATURE =1000.
TIME STEP =60
TIME =4320.00
□ - 1.0E20
○ - 1.0E19
△ - 1.0E18
+ - 1.0E17
× - 1.0E16
◇ - 1.0E15
DRY O₂
BORON
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0


χ^2 =0.0000
TEMPERATURE =1000.
TIME STEP =80
TIME =5760.00
□ - 1.0E20
⊙ - 1.0E19
△ - 1.0E18
+ - 1.0E17
× - 1.0E16
◇ - 1.0E15
DRY O_2
BORON
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0


X2 =0.0000
TEMPERATURE =1000.
TIME STEP =100
TIME =7200.00
- 1.0E20
- 1.0E18
- 1.0E17
- 1.0E15
DRY O2
BORON



TEMP = 900.0
THICKNESS = 0.0 CM-4
NORMALIZING TIME = 1400.0 MIN
AMBIENT = DRY OXYGEN
BORON
JUNCTION DEPTH
NORMALIZED TIME
10^-0
10^-1
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


TEMP = 900.0
NORMALIZING TIME = 1400.0 MIN
AMBIENT = DRY OXYGEN BORON
Qimp = 10^12 cm^-2
5×10^12
10^13
5×10^13
10^14
SHEET RESISTANCE
10^5
10^4
10^3
10^2
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
NORMALIZED TIME

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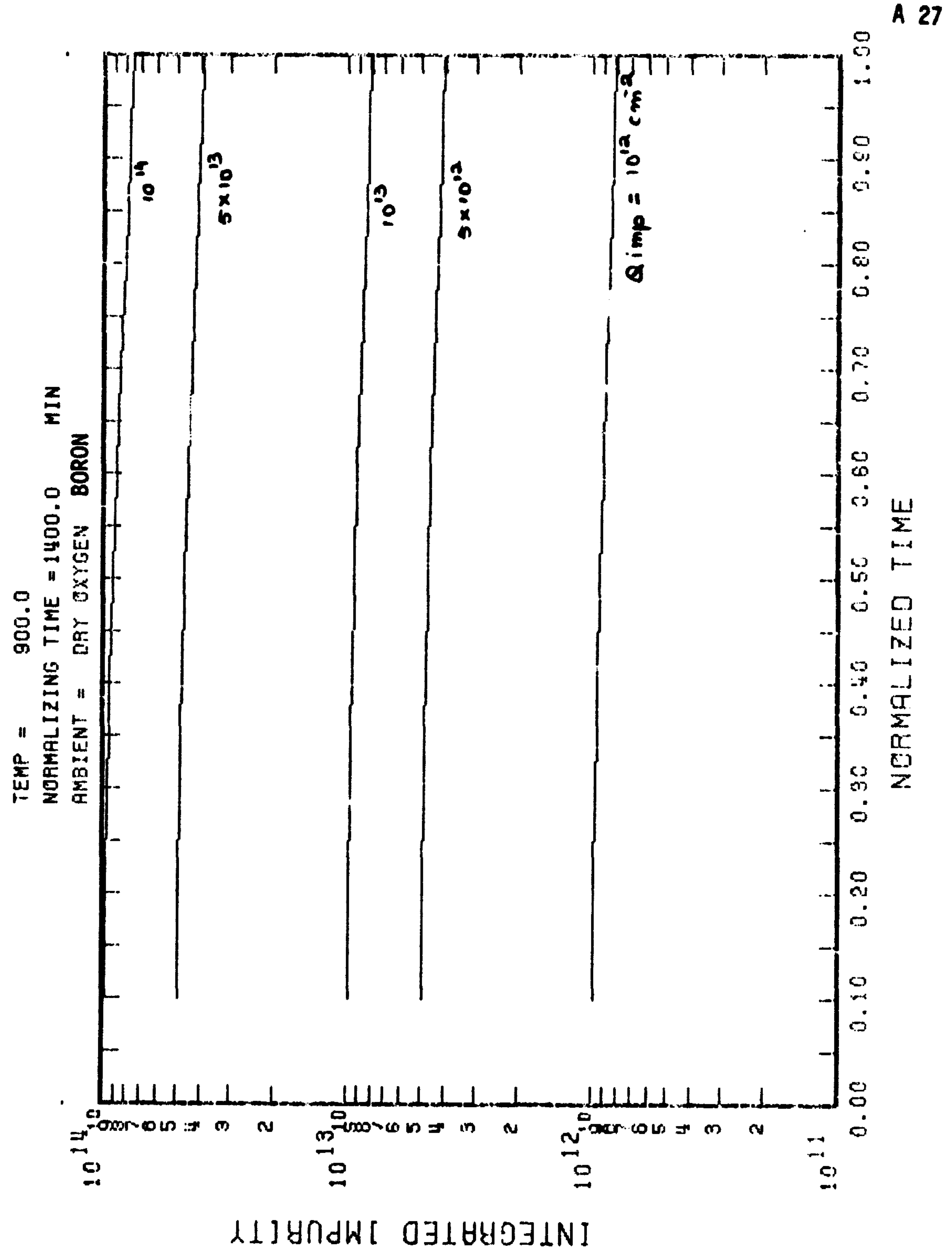

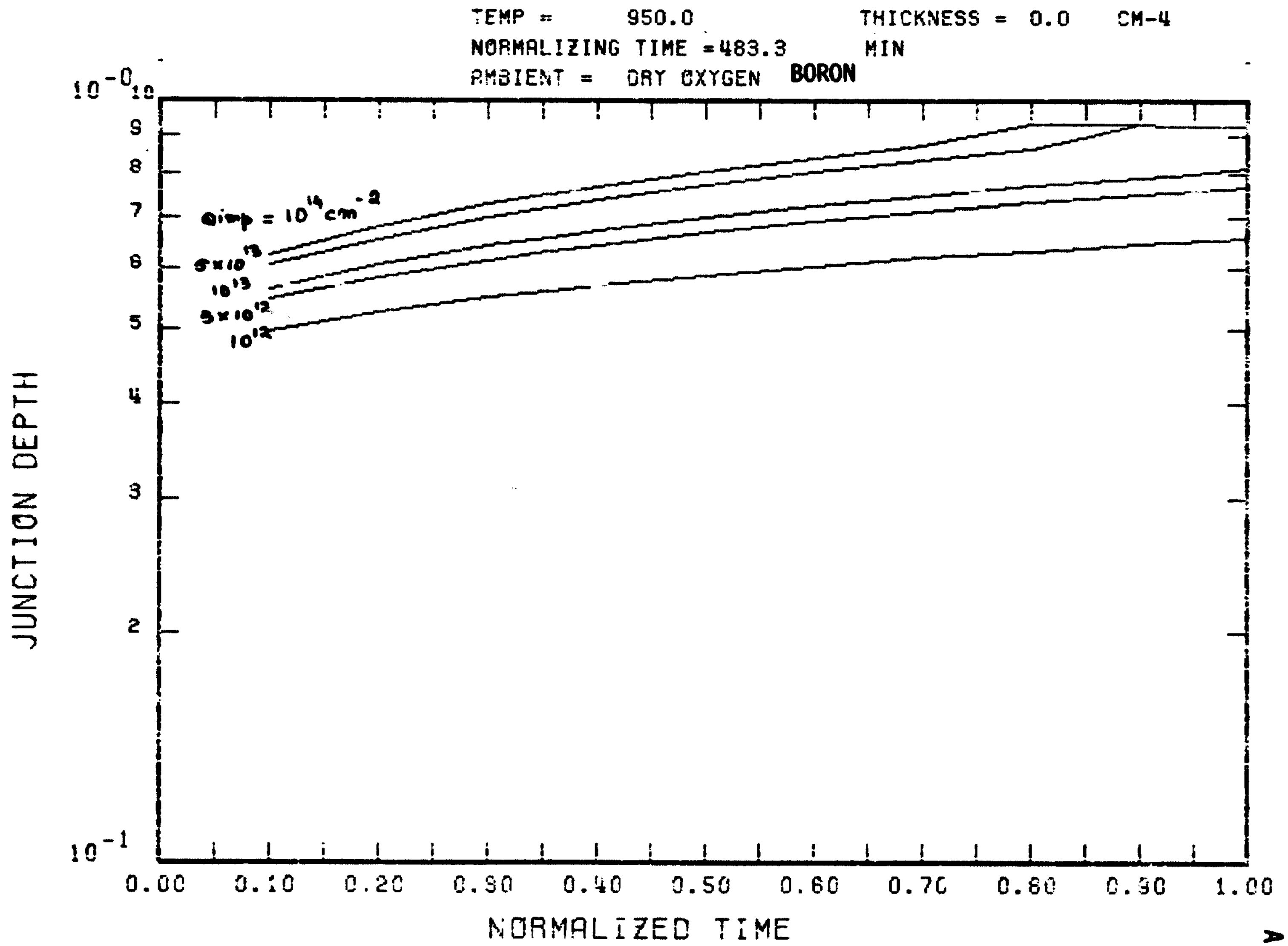

TEMP = 950.0
THICKNESS = 0.0 CM-4
NORMALIZING TIME =483.3 MIN
AMBIENT = DRY OXYGEN
BORON
Qimp = 10^14 cm^-2
5x10^13
10^13
5x10^12
10^12
JUNCTION DEPTH
10^-0
10
9
8
7
6
5
4
3
2
10^-1
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
NORMALIZED TIME

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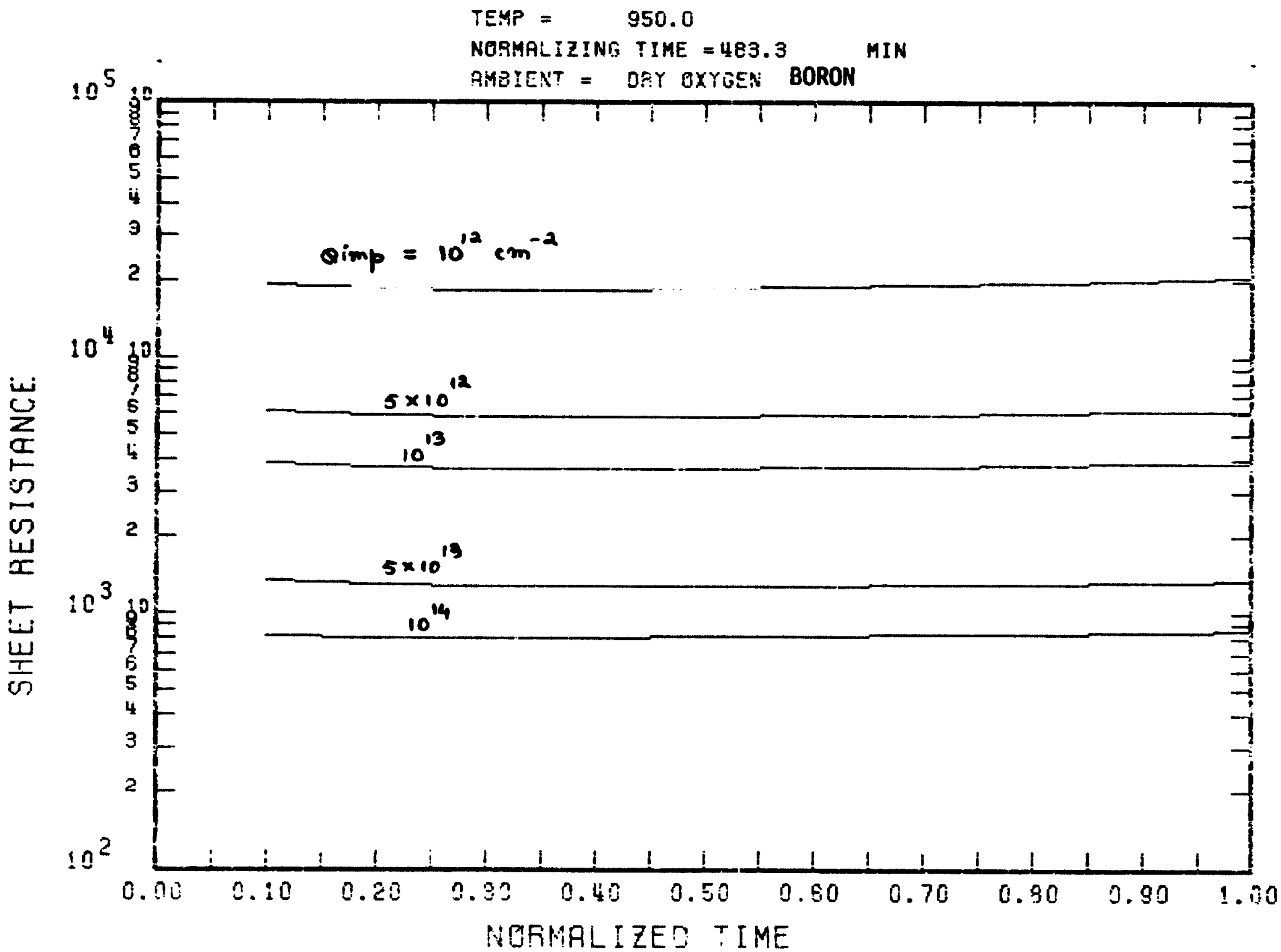

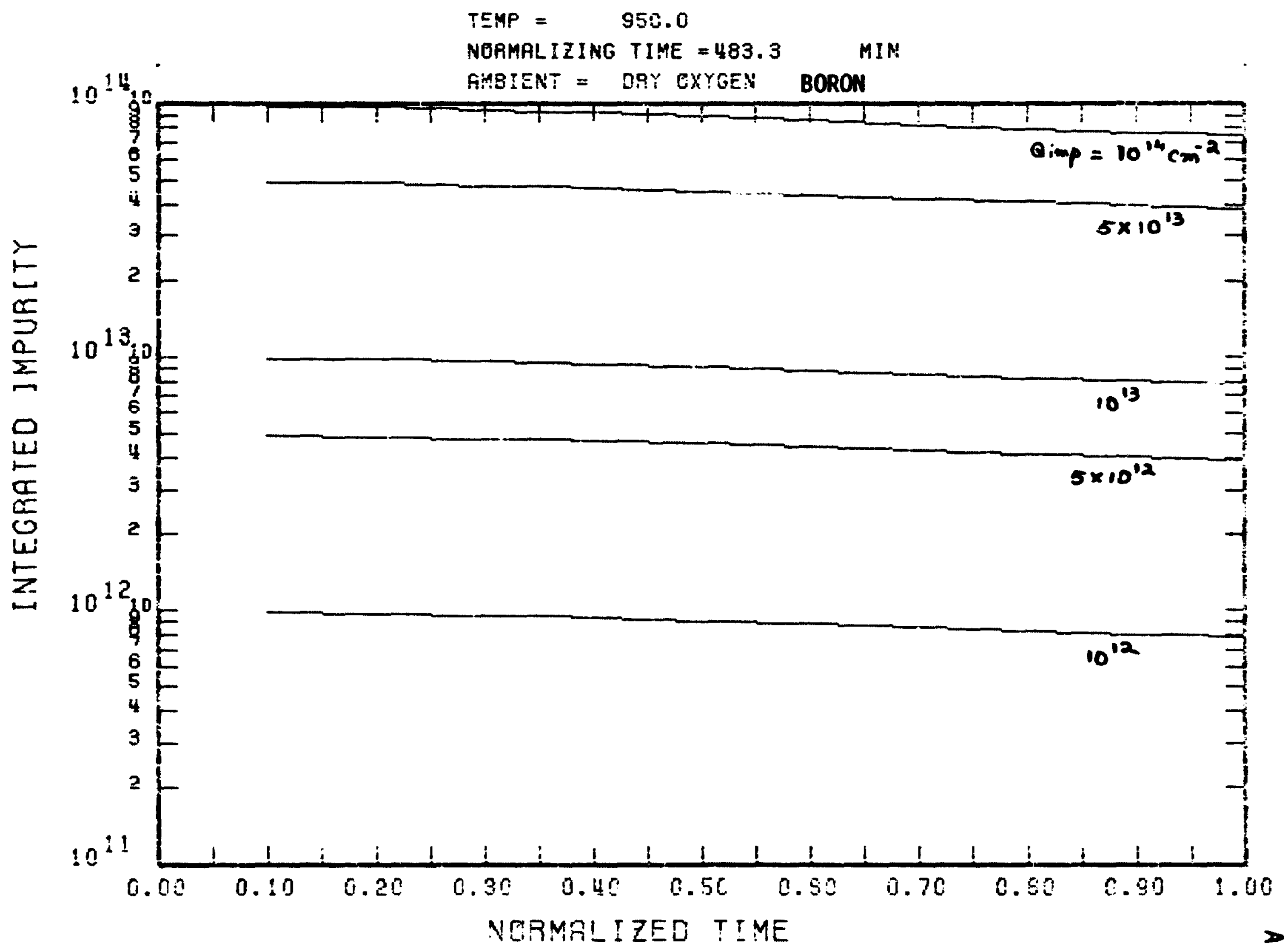
TEMP = 950.0
NORMALIZING TIME =483.3 MIN
AMBIENT = DRY OXYGEN BORON
Qimp = 10^14 cm^-2
5x10^13
10^13
5x10^12
10^12
INTEGRATED IMPURITY
NORMALIZED TIME
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
10^14
10^13
10^12
10^11

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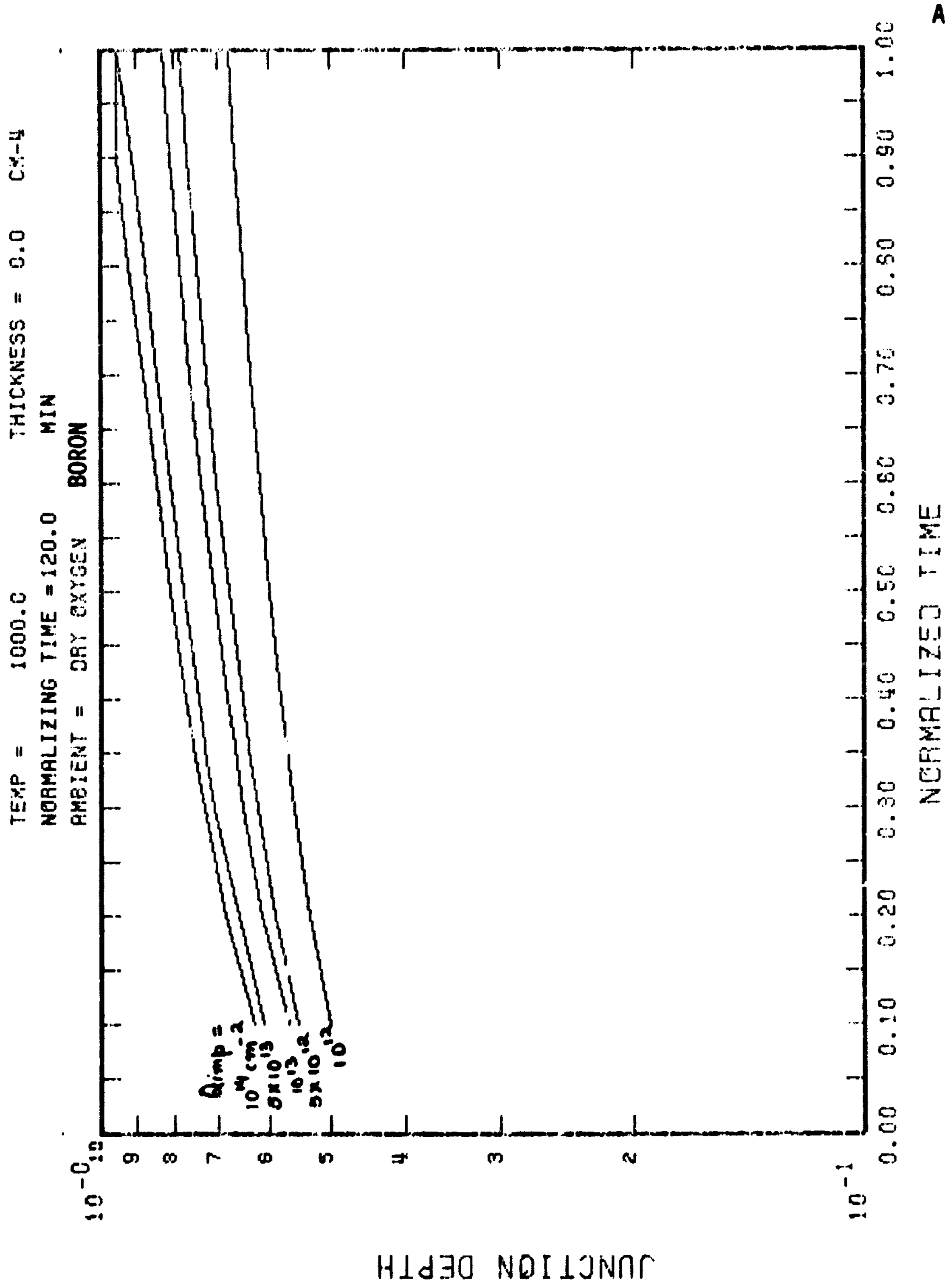

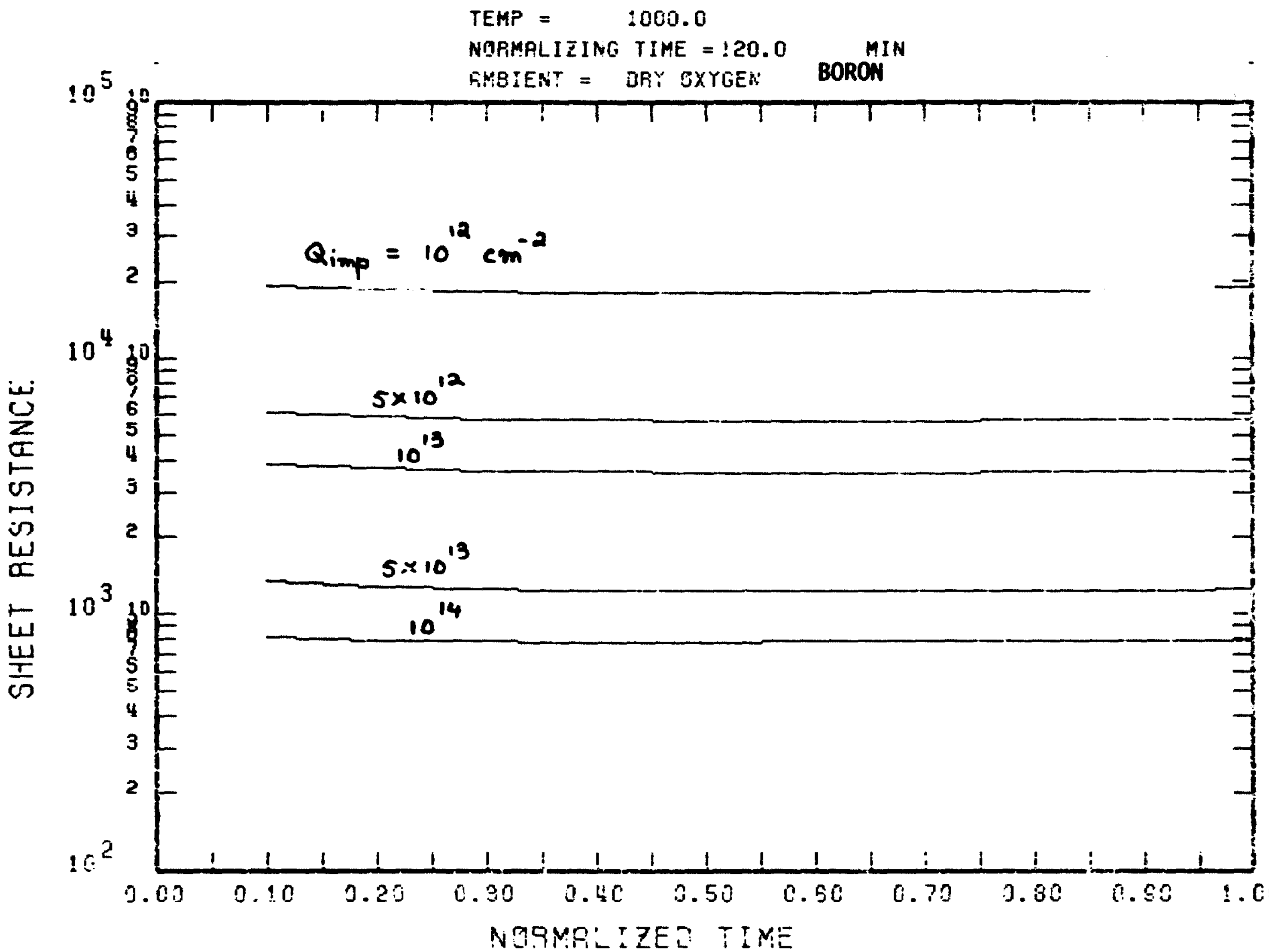
TEMP = 1000.0
NORMALIZING TIME = 120.0 MIN
AMBIENT = DRY OXYGEN
BORON
$Q_{imp} = 10^{12}\ cm^{-2}$
5×10^{12}
10^{13}
5×10^{13}
10^{14}
SHEET RESISTANCE
NORMALIZED TIME
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
10^2 10^3 10^4 10^5

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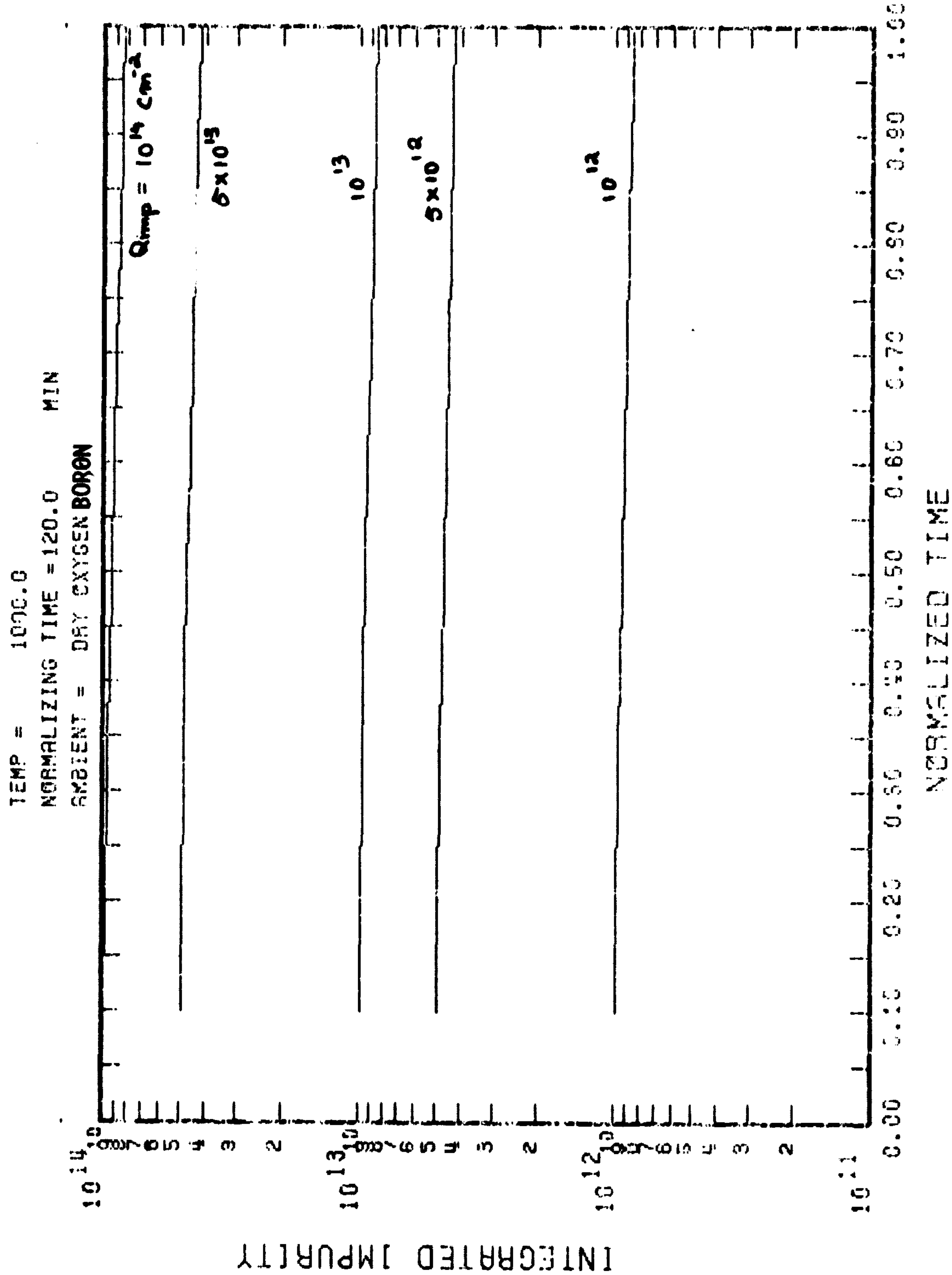
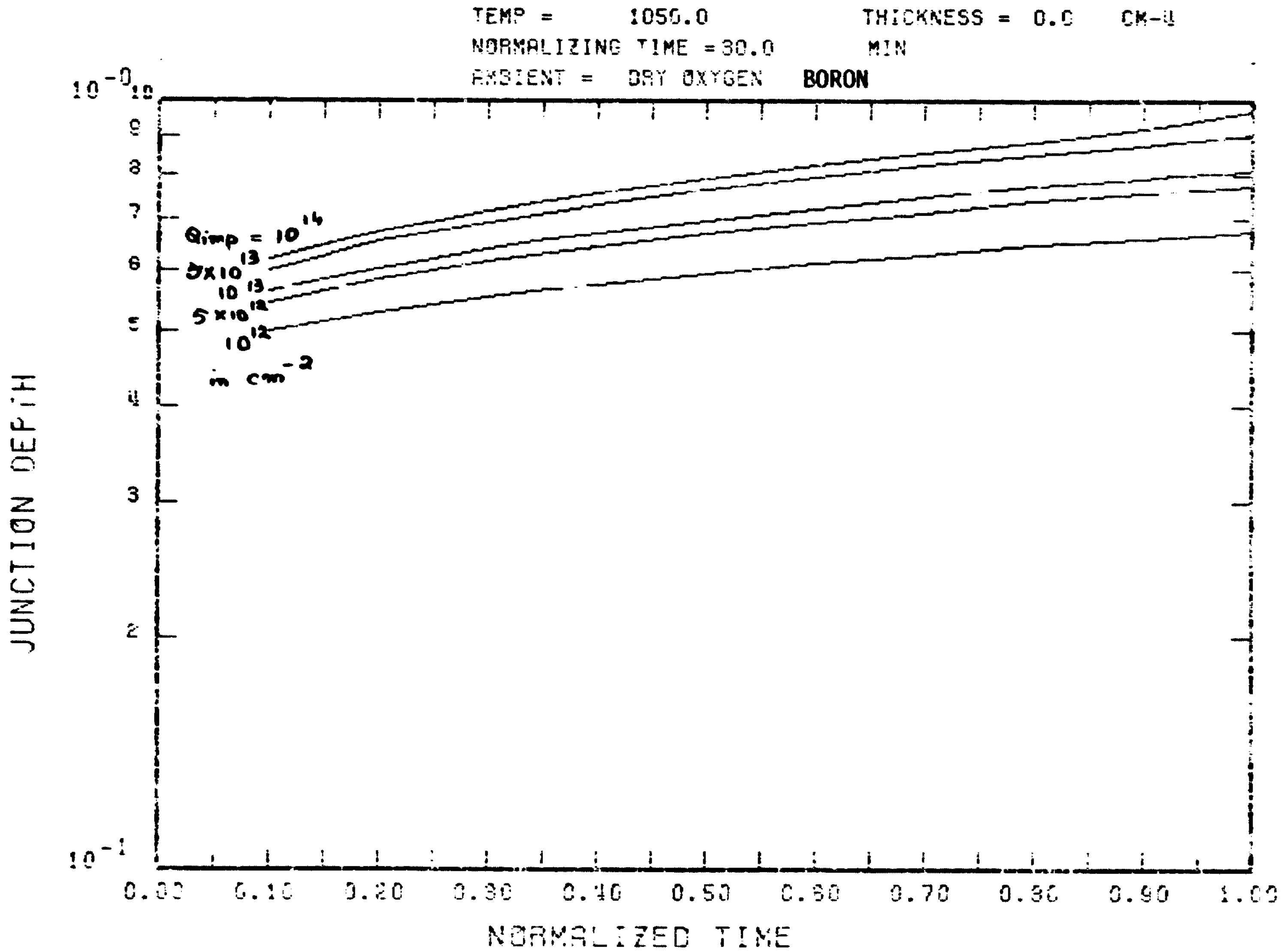
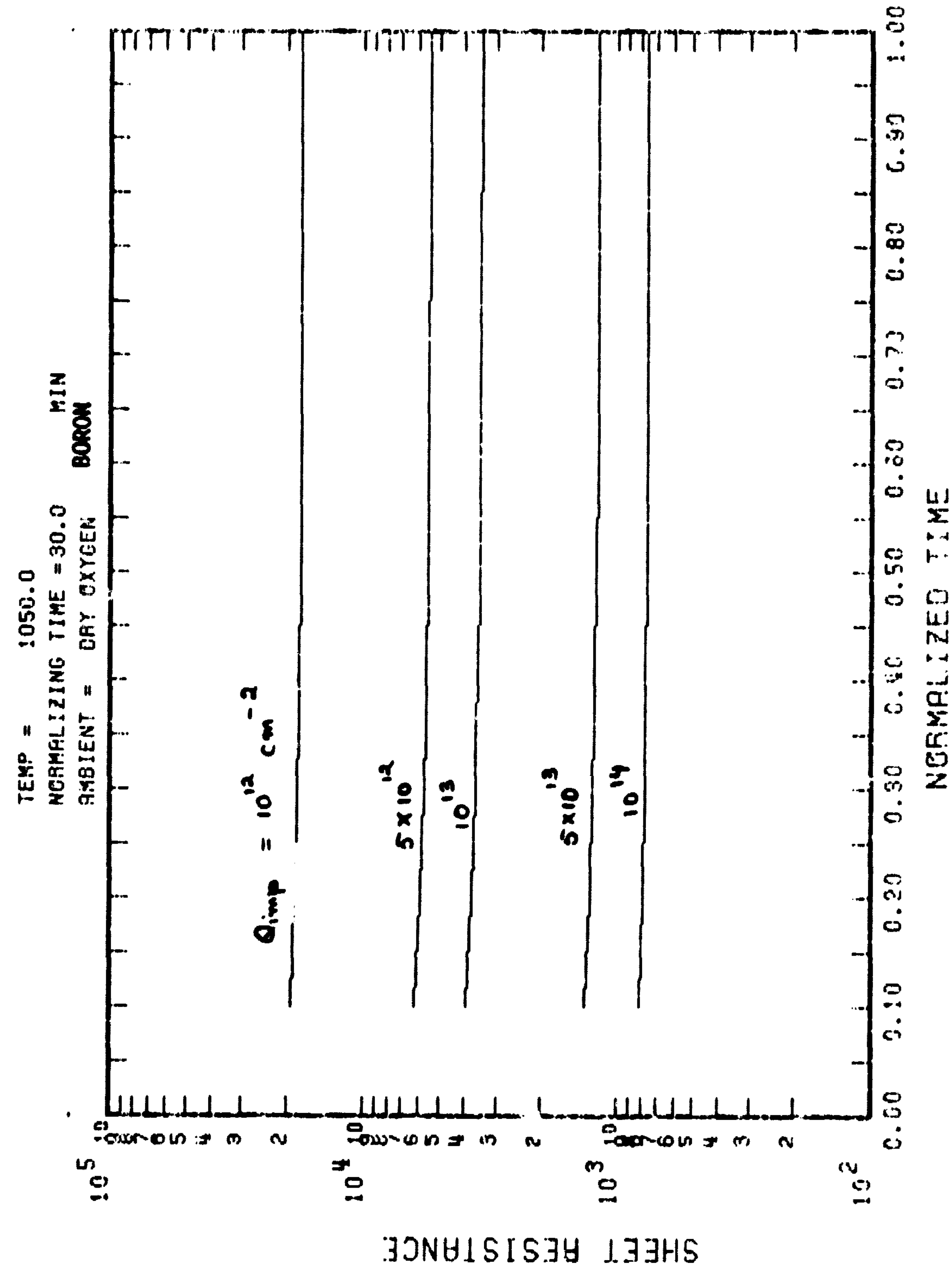
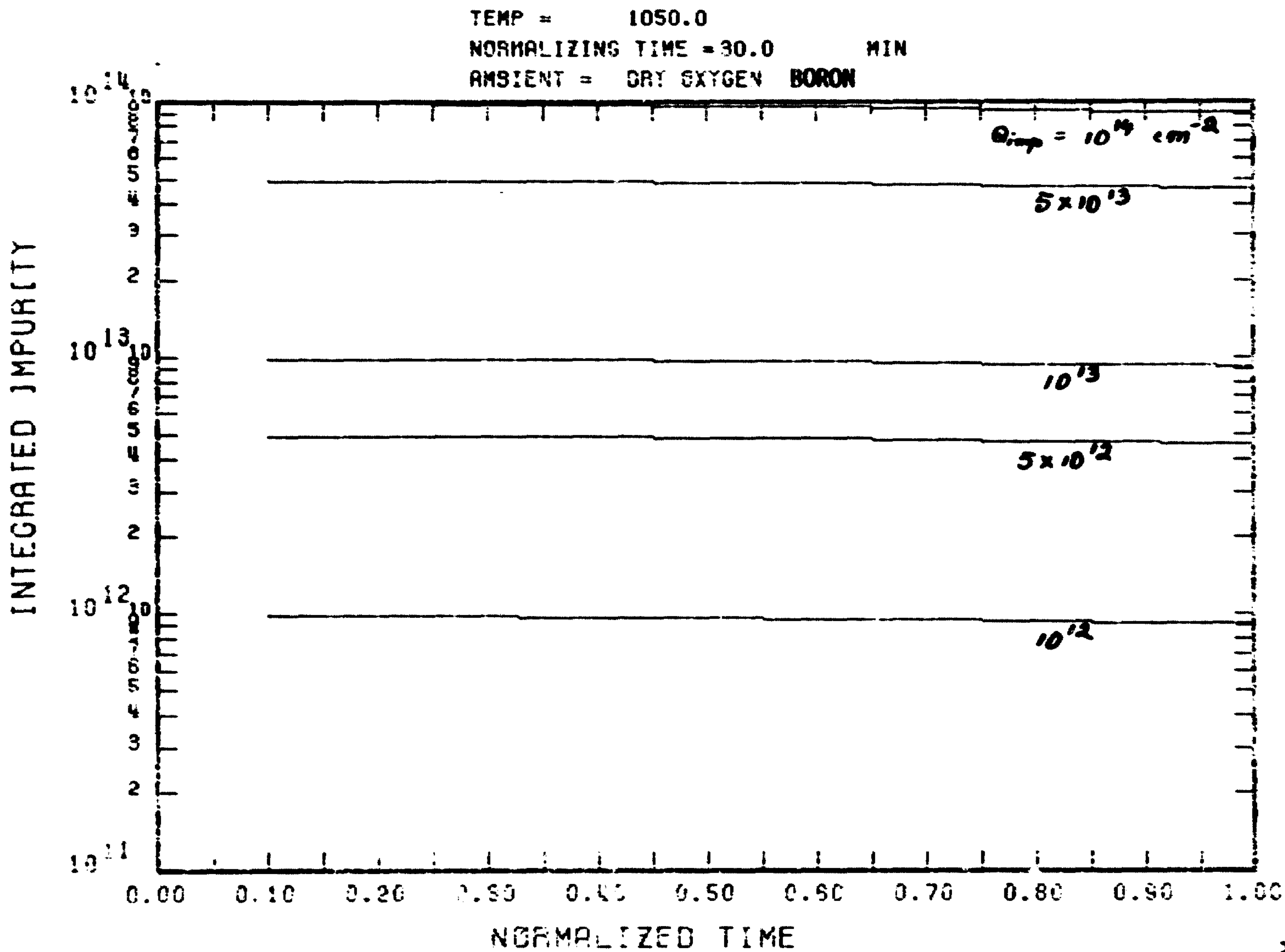
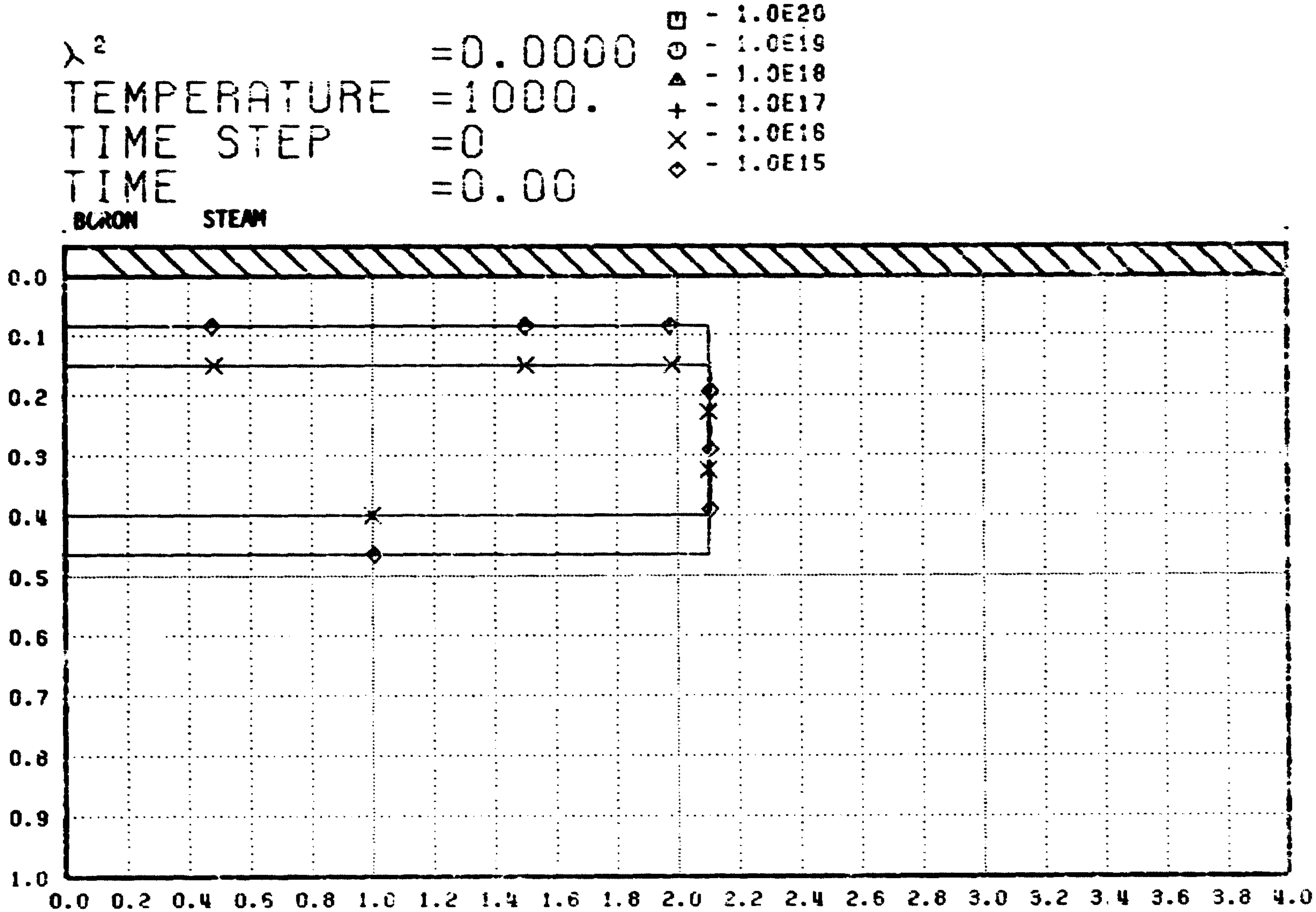



TEMP = 1050.0
THICKNESS = 0.0 CM-4
NORMALIZING TIME = 30.0 MIN
AMBIENT = DRY OXYGEN
BORON
Qimp = 10^14
5x10^13
10^13
5x10^12
10^12
in cm^-2
JUNCTION DEPTH
10^-0
10^-1
9
8
7
6
5
4
3
2
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
NORMALIZED TIME

ORIGINAL PAGE IS
OF POOR QUALITY




TEMP = 1050.0
NORMALIZING TIME = 30.0 MIN
AMBIENT = DRY OXYGEN BORON
$Q_{imp} = 10^{14}\ cm^{-2}$
5×10^{13}
10^{13}
5×10^{12}
10^{12}
INTEGRATED IMPURITY
NORMALIZED TIME
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
10^{14} 10^{13} 10^{12} 10^{11}



λ^2 =0.0000
TEMPERATURE =1000.
TIME STEP =0
TIME =0.00
□ - 1.0E20
⊖ - 1.0E19
▲ - 1.0E18
+ - 1.0E17
× - 1.0E16
◇ - 1.0E15
BORON
STEAM
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0

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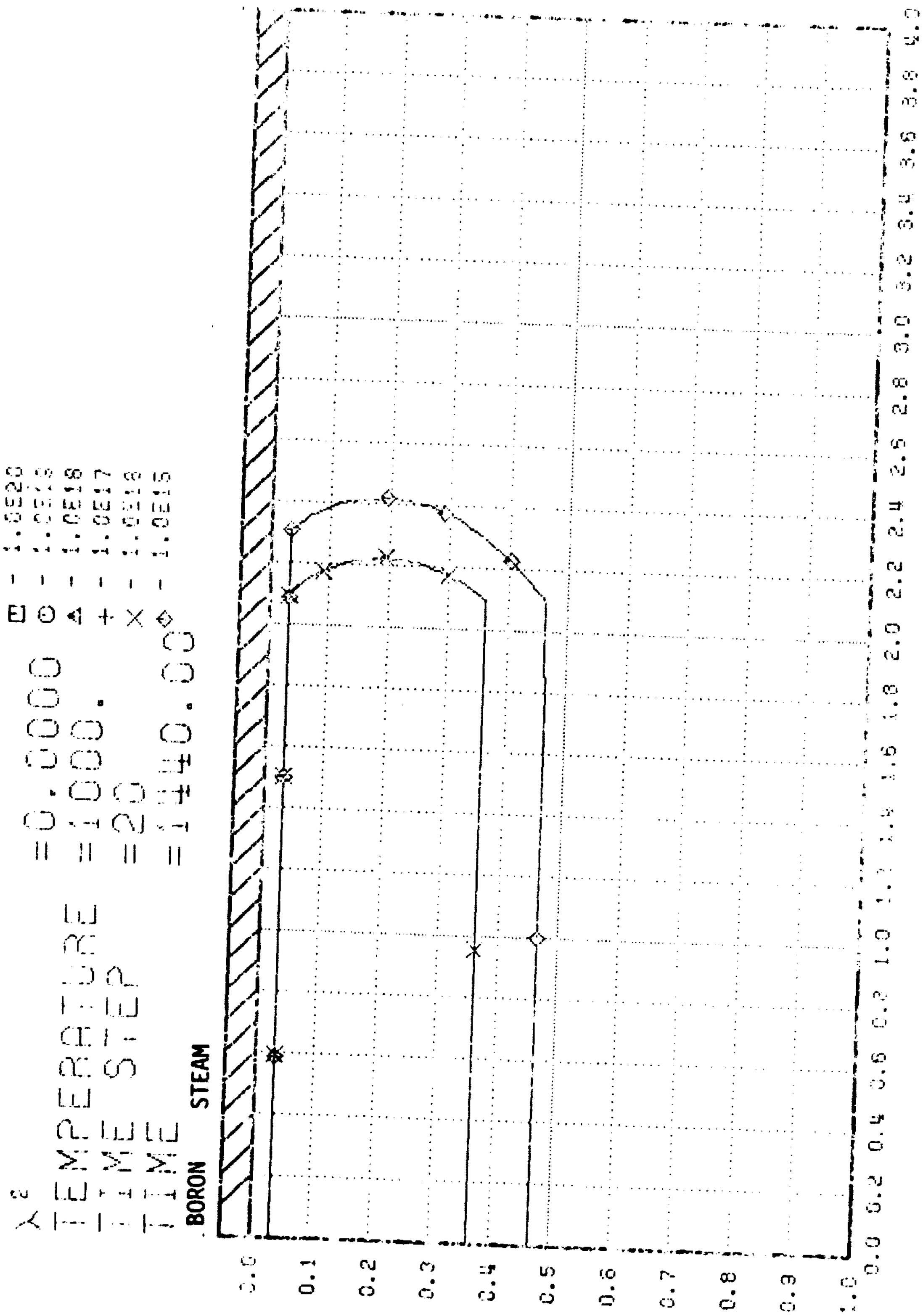
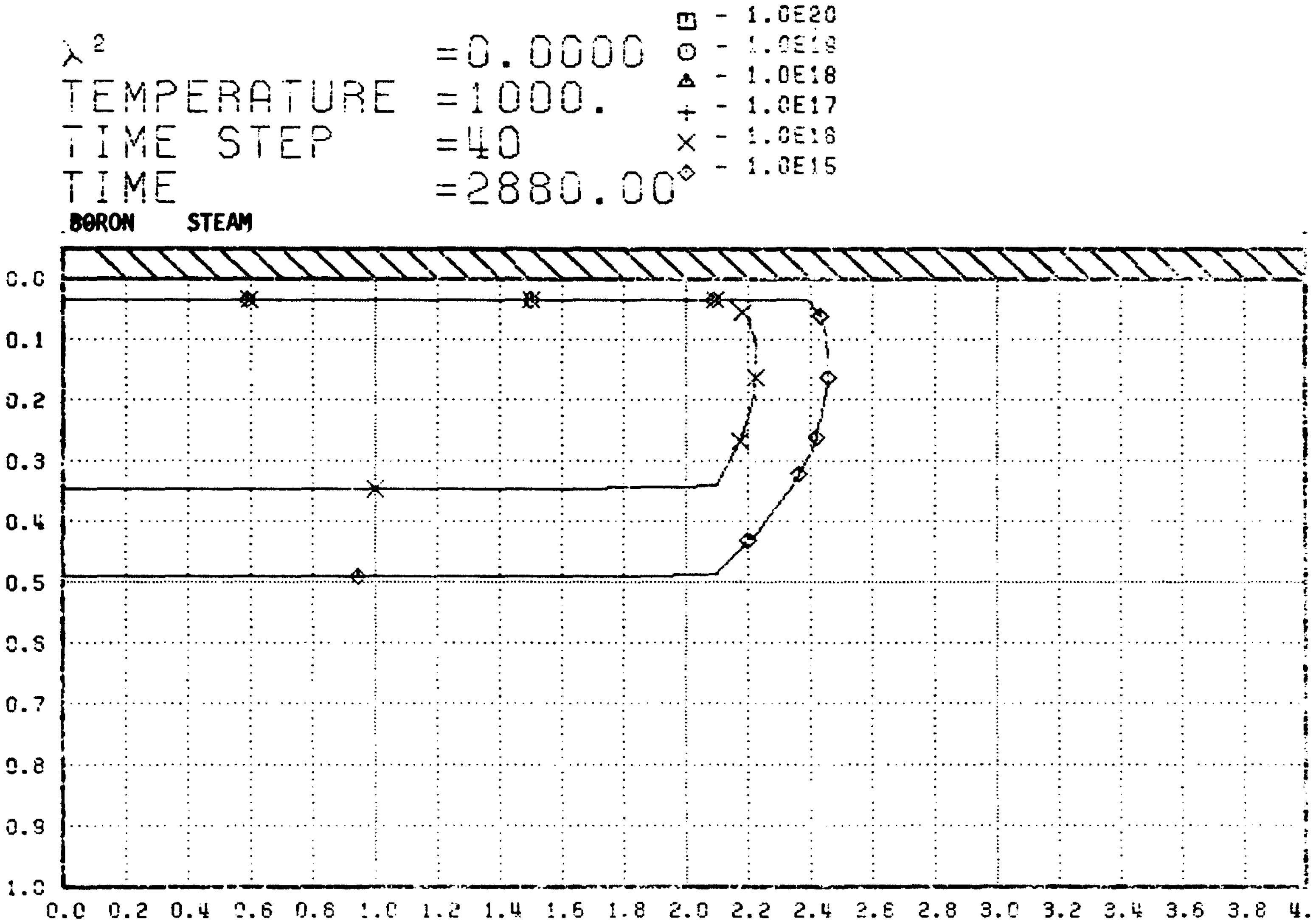
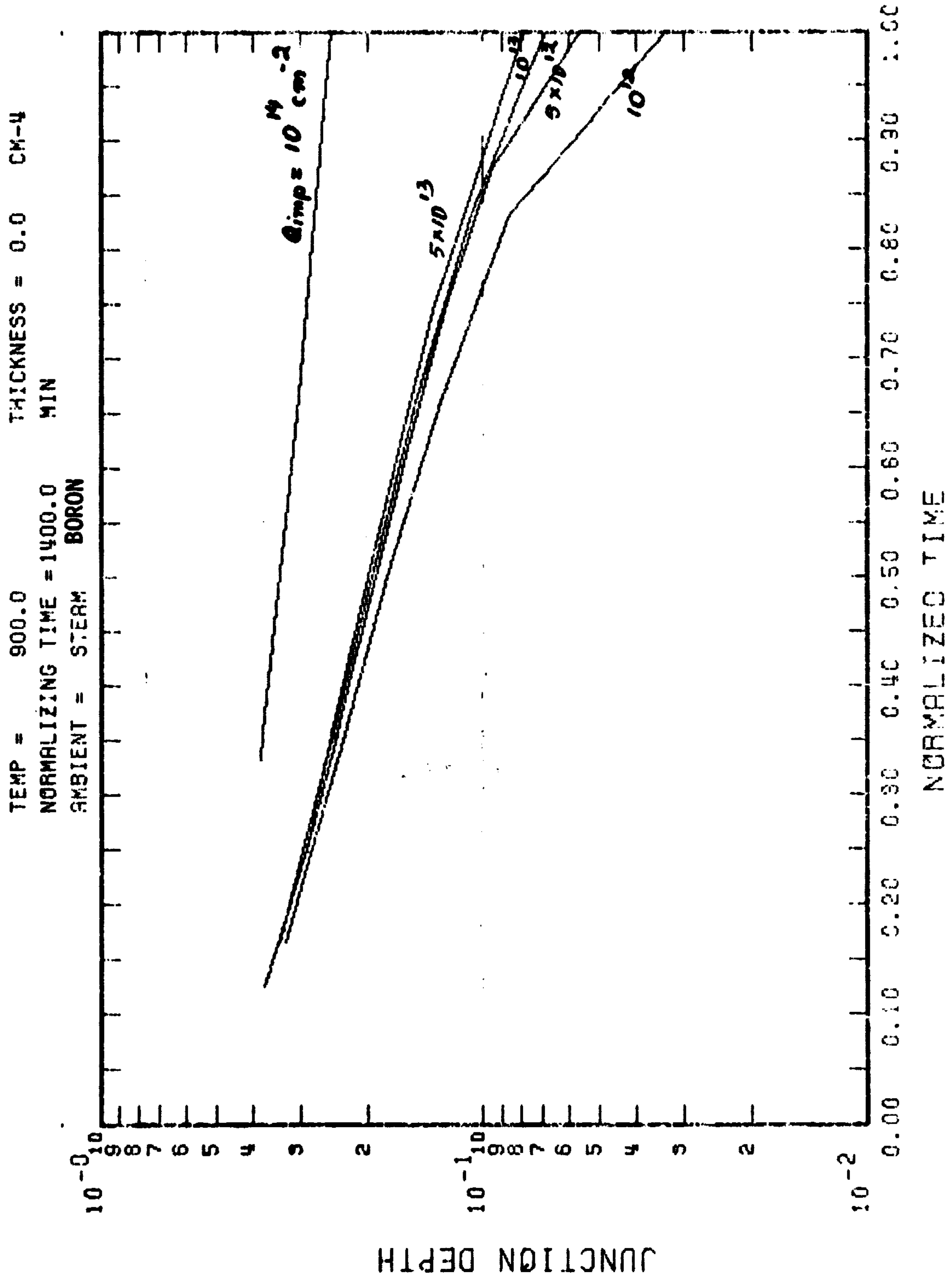
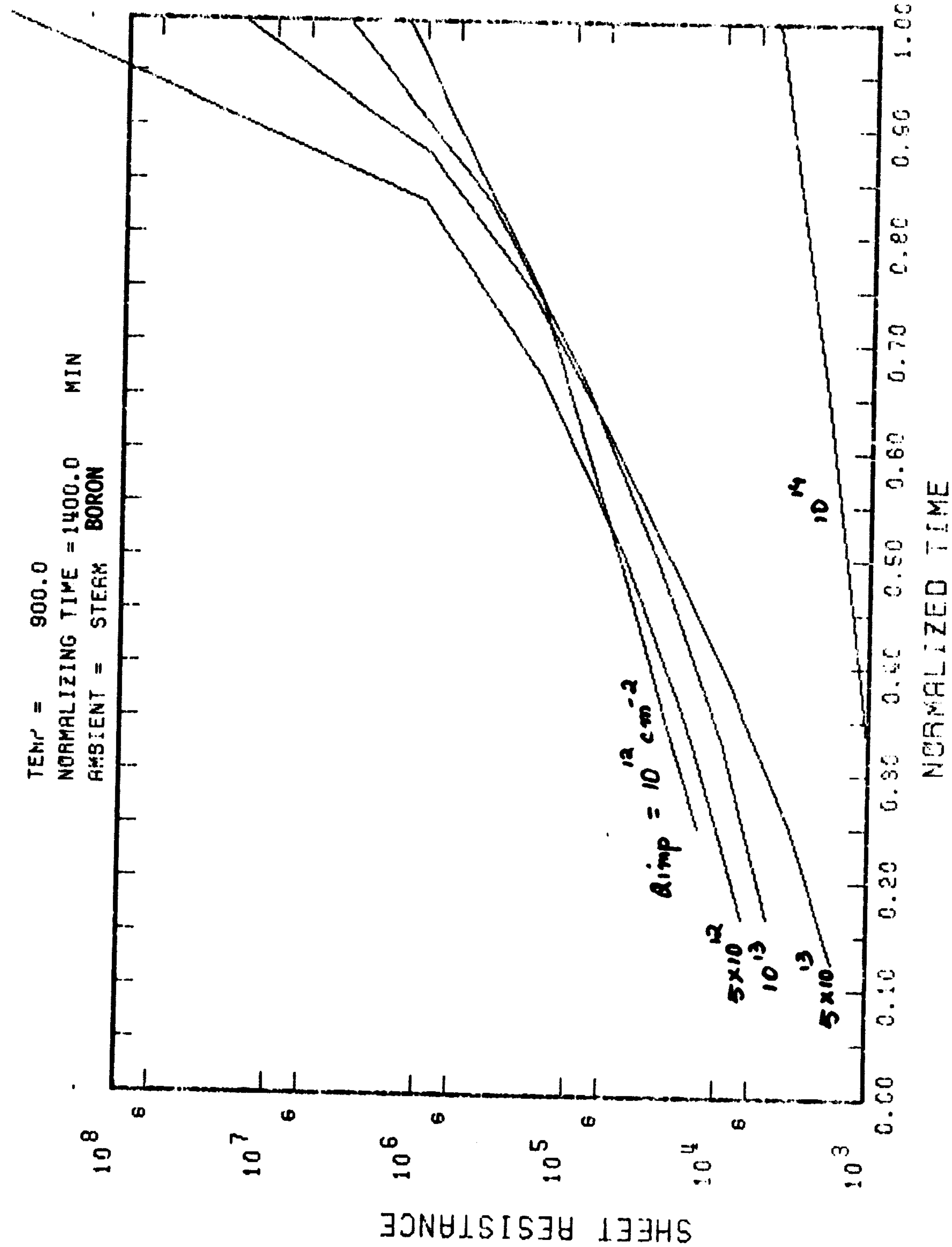



λ 2 =0.0000
TEMPERATURE =1000.
TIME STEP =40
TIME =2880.00
□ - 1.0E20
○ - 1.0E19
△ - 1.0E18
+ - 1.0E17
× - 1.0E16
◇ - 1.0E15
BORON
STEAM
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0


TEMP = 900.0 THICKNESS = 0.0 CM-4
NORMALIZING TIME =1400.0 MIN
AMBIENT = STEAM BORON
Qimp = 10^14 cm^-2
5x10^13
10^13
5x10^12
10^12
NORMALIZED TIME
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JUNCTION DEPTH
10^-2 10^-1 10^0


TEMP = 900.0
NORMALIZING TIME = 1400.0 MIN
AMBIENT = STEAM BORON
Qimp = 10^12 cm^-2
5x10^12
10^13
5x10^13
10^14
NORMALIZED TIME
SHEET RESISTANCE
10^3
10^4
10^5
10^6
10^7
10^8
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

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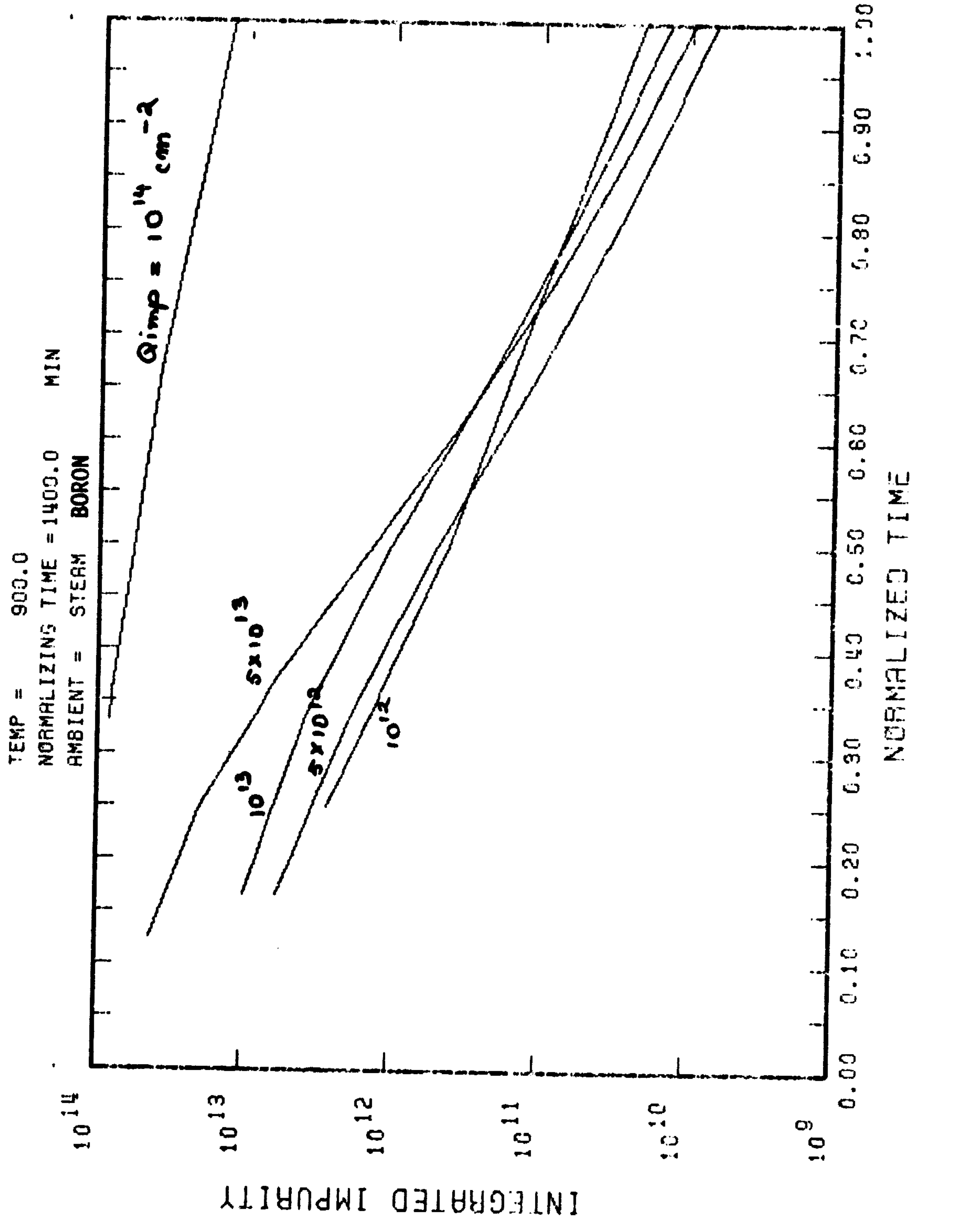
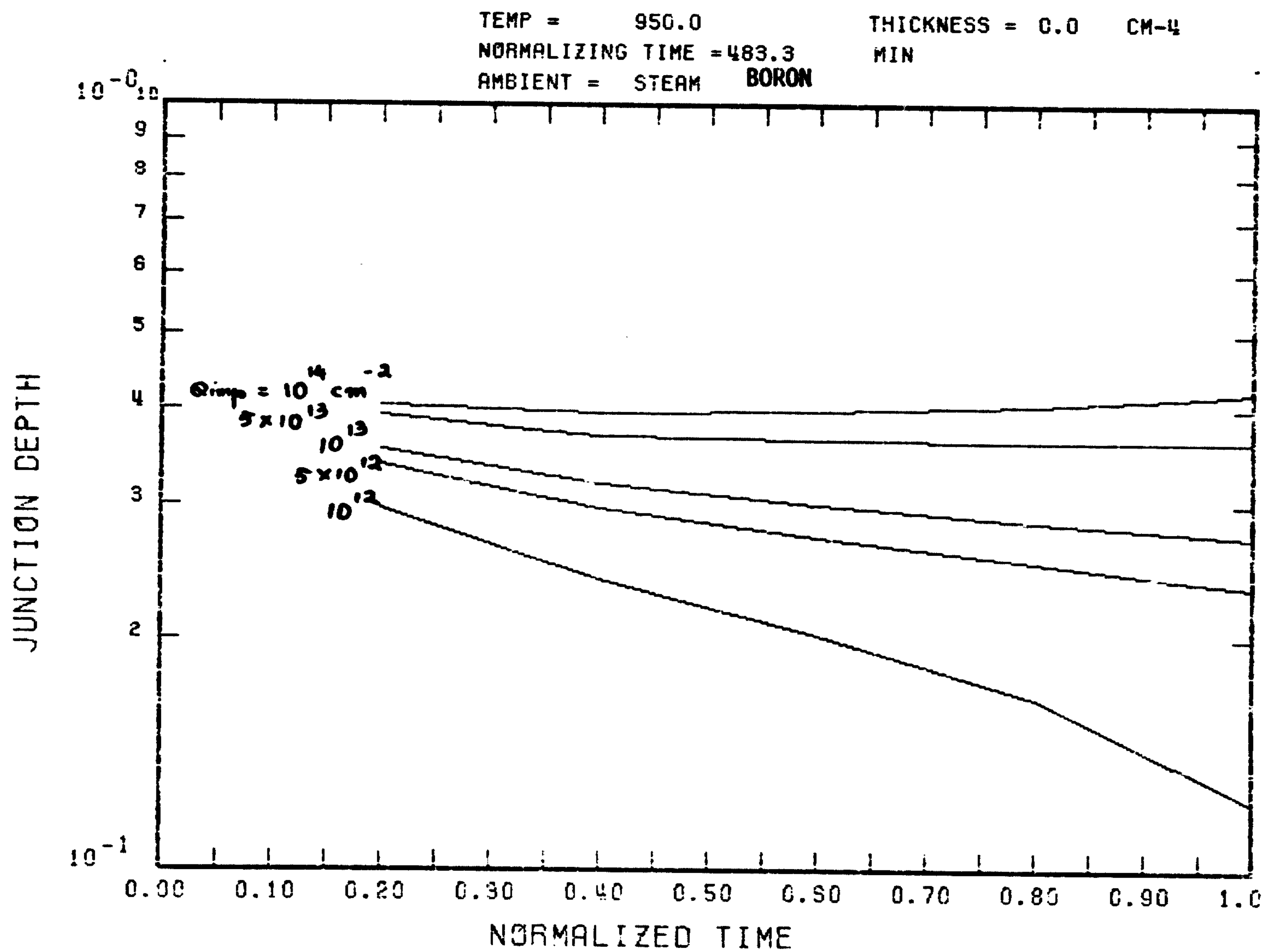
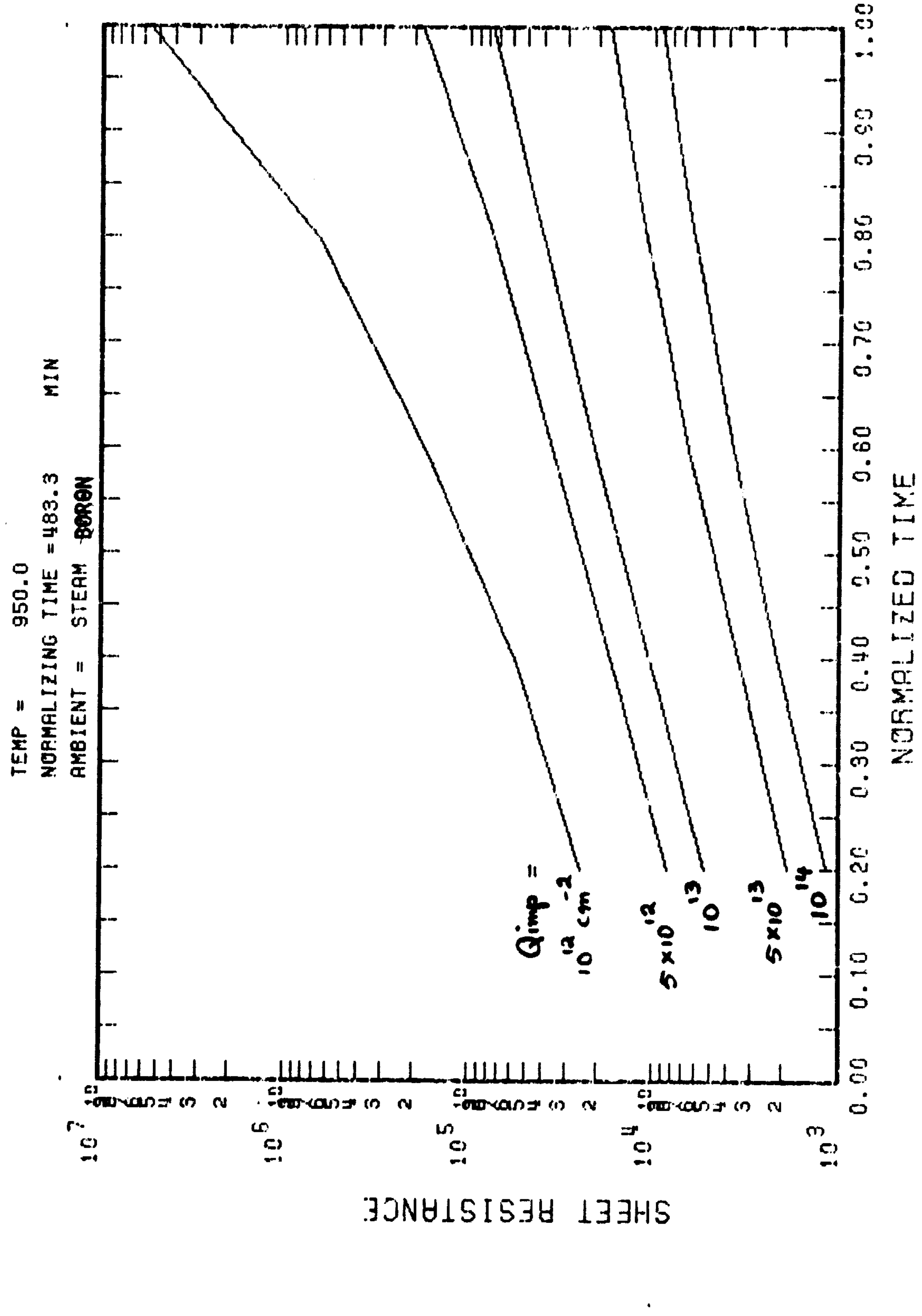
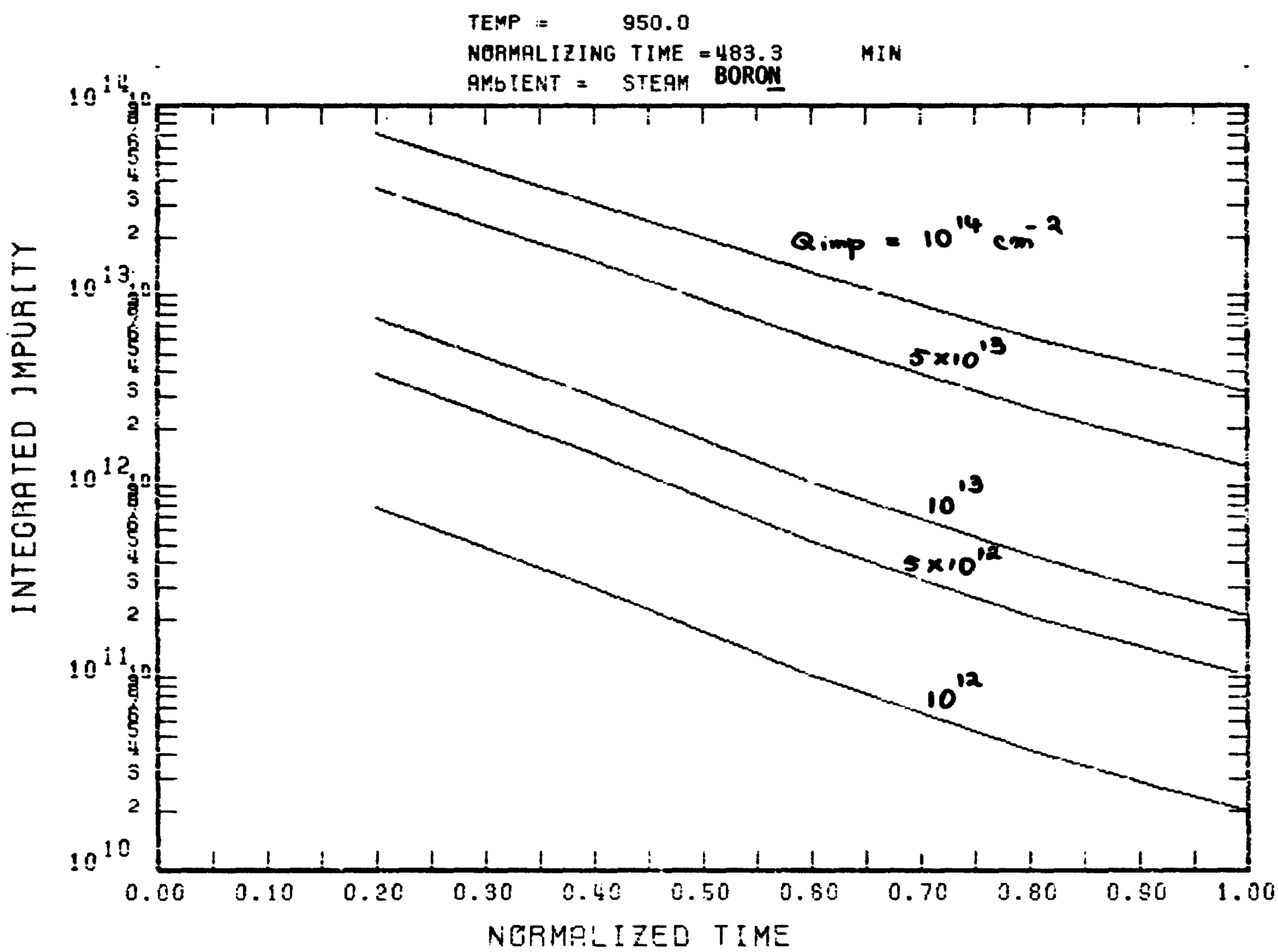




TEMP = 950.0
THICKNESS = 0.0 CM-4
NORMALIZING TIME = 483.3 MIN
AMBIENT = STEAM
BORON
Qimp = 10^14 cm^-2
5x10^13
10^13
5x10^12
10^12
JUNCTION DEPTH
10^-0
10^-1
9
8
7
6
5
4
3
2
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
NORMALIZED TIME


TEMP = 950.0
NORMALIZING TIME = 483.3 MIN
AMBIENT = STEAM BORON
Q_{imp} =
10^{12} cm^{-2}
5×10^{12}
10^{13}
5×10^{13}
10^{14}
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
NORMALIZED TIME
10^3
10^4
10^5
10^6
10^7
SHEET RESISTANCE


TEMP = 950.0
NORMALIZING TIME =483.3 MIN
AMbIENT = STEAM BORON
INTEGRATED IMPURITY
NORMALIZED TIME
Qimp = 10^14 cm^-2
5x10^13
10^13
5x10^12
10^12
10^10
10^11
10^12
10^13
10^14
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

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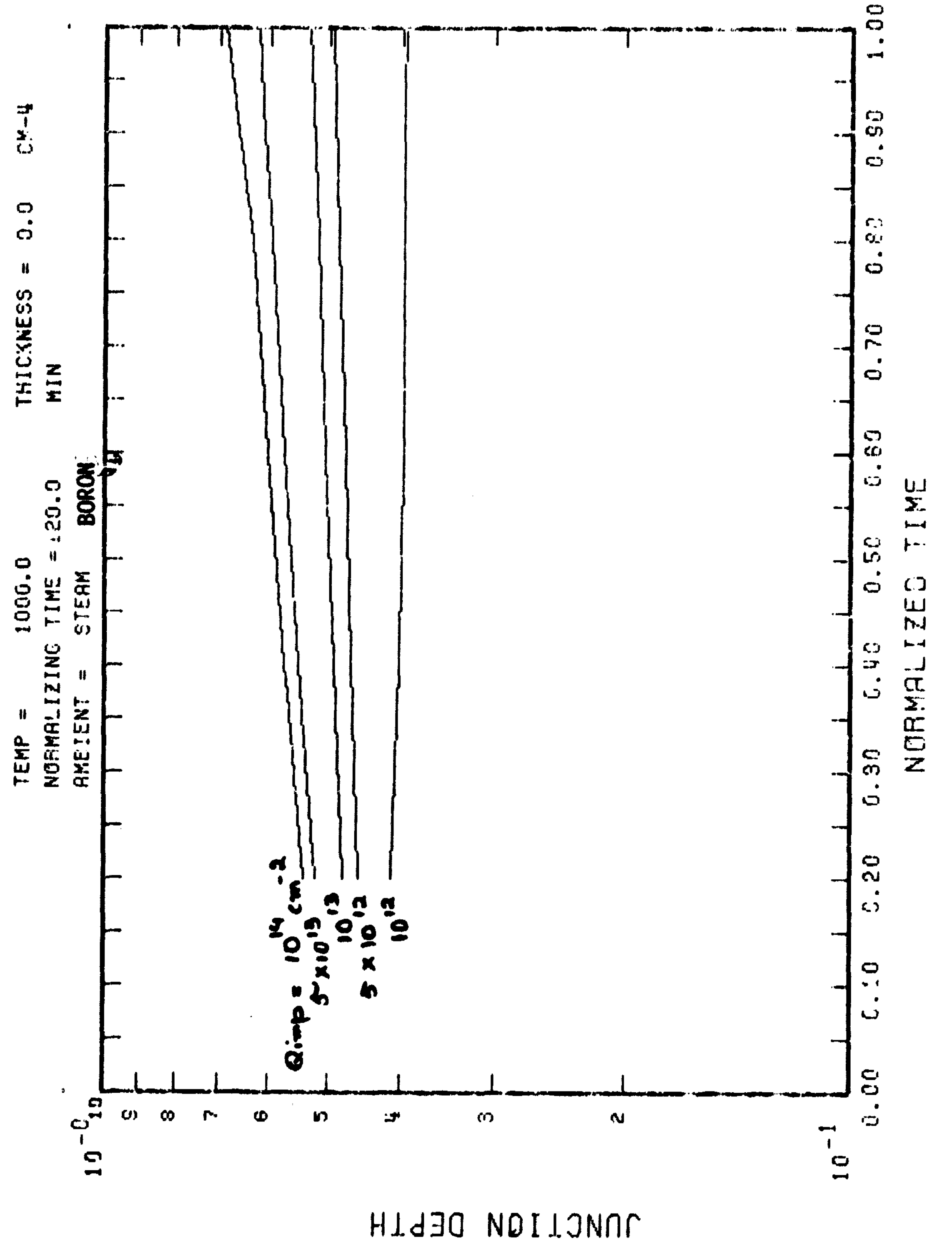

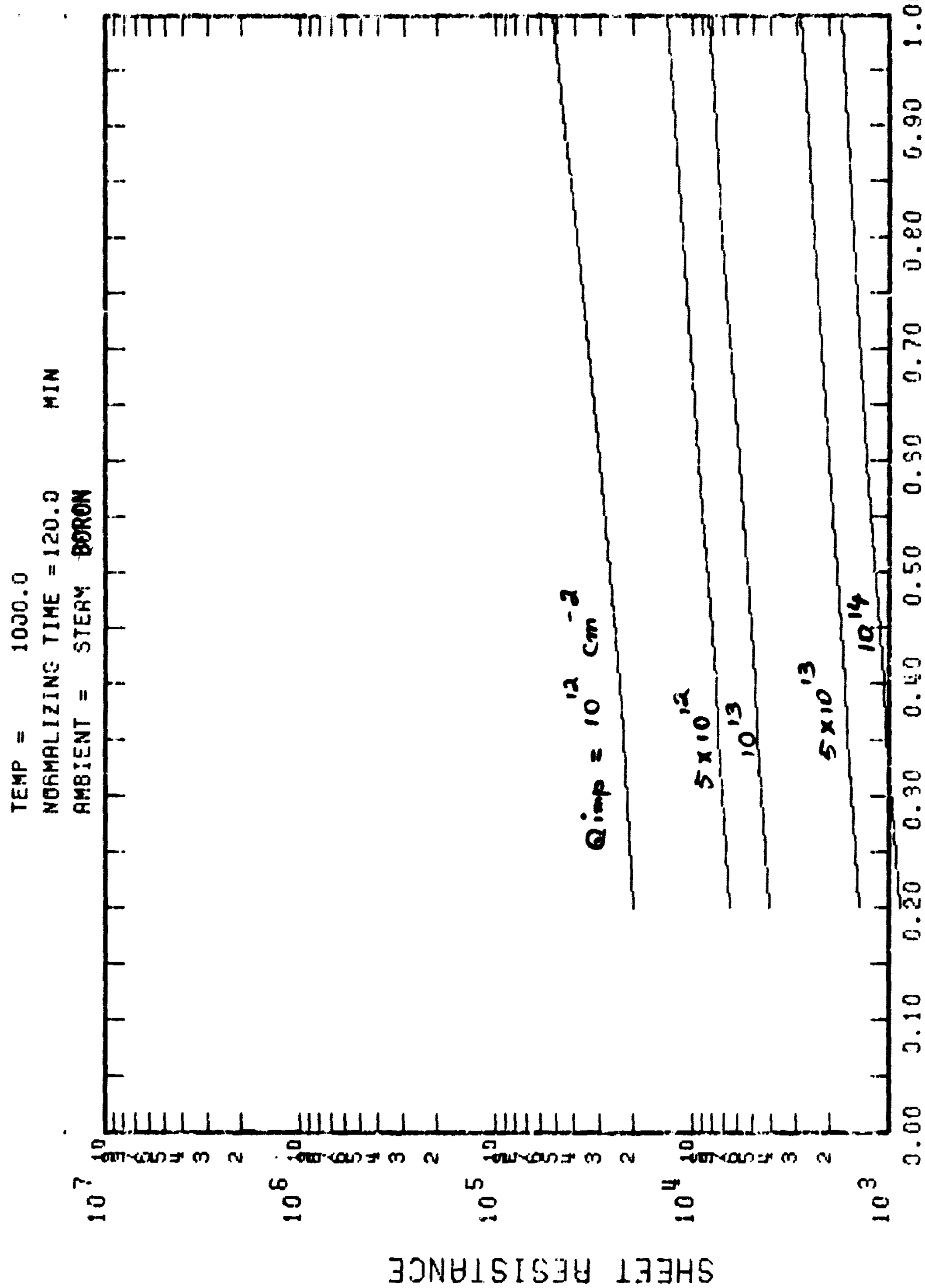

TEMP = 1000.0
NORMALIZING TIME = 120.0 MIN
AMBIENT = STEAM BORON
Qimp = 10^12 cm^-2
5x10^12
10^13
5x10^13
10^14
NORMALIZED TIME
SHEET RESISTANCE

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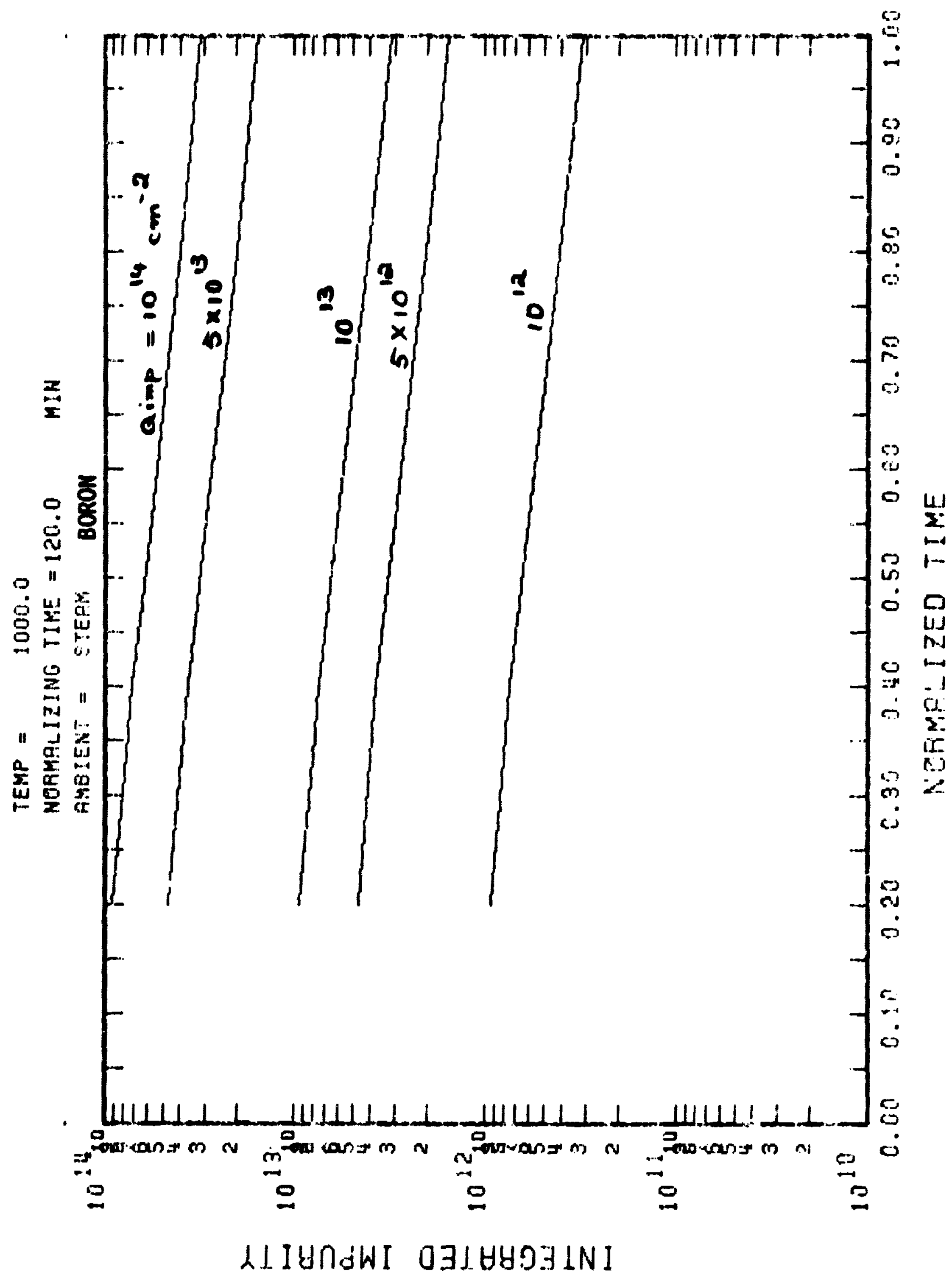
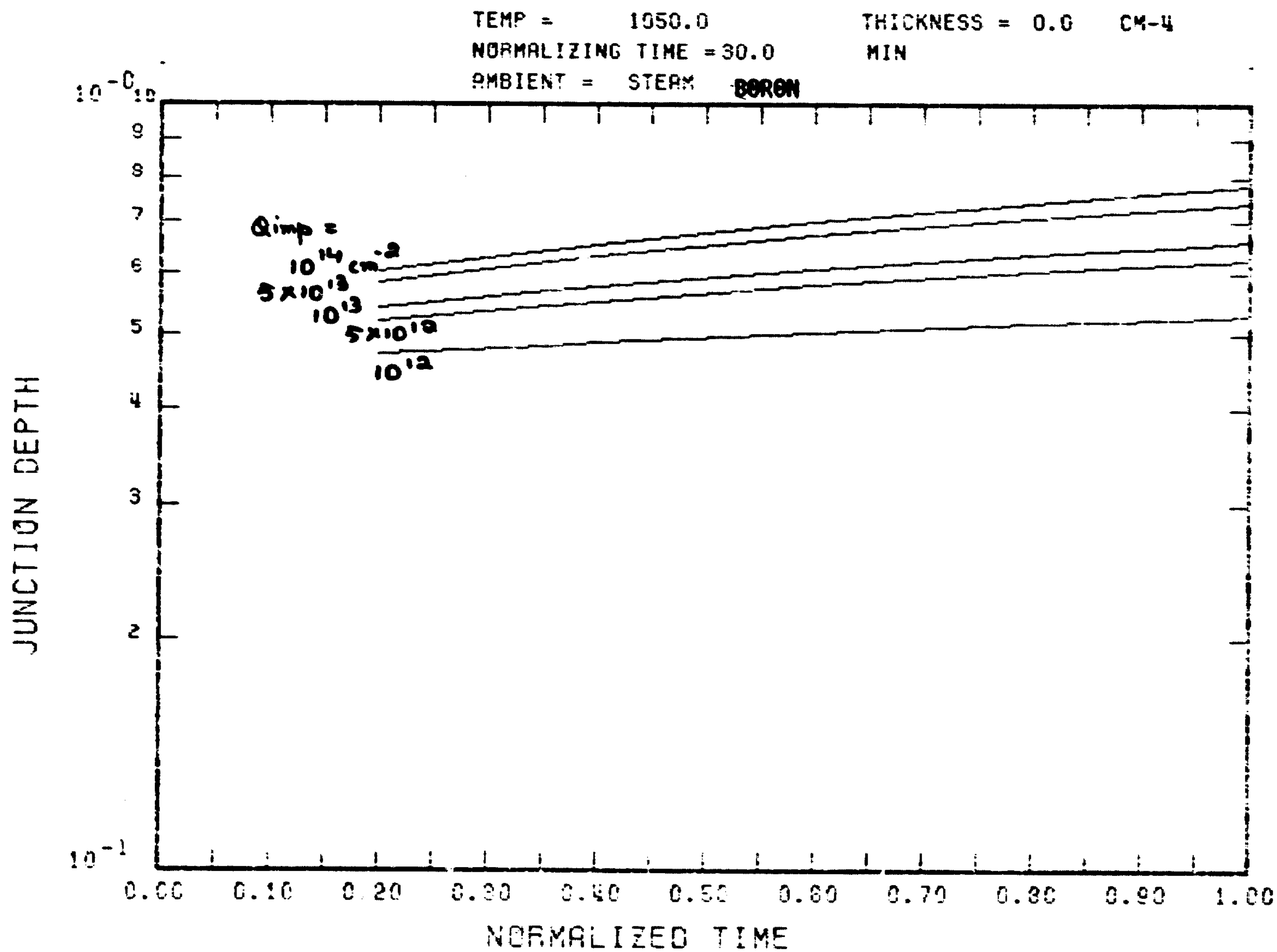
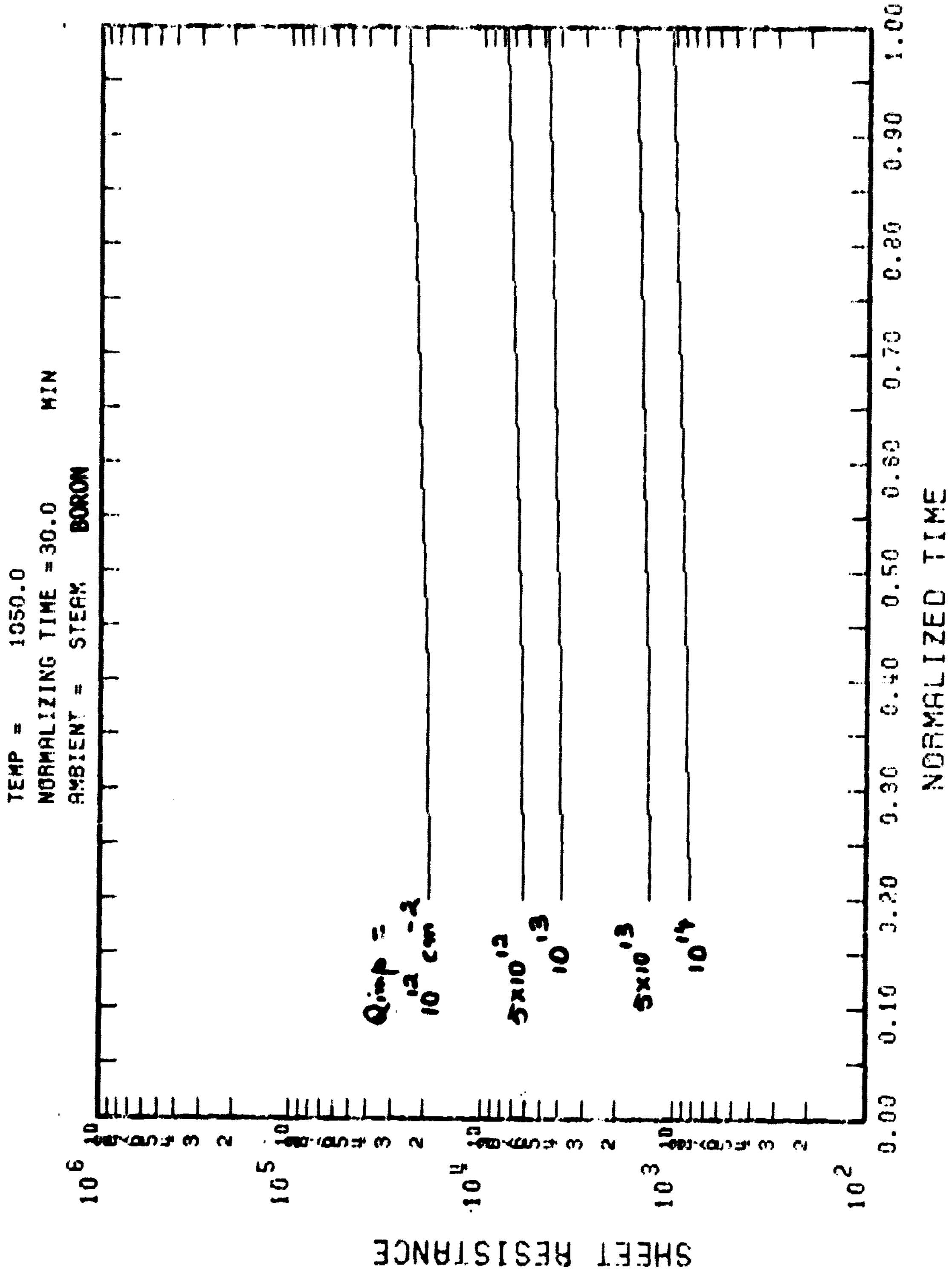
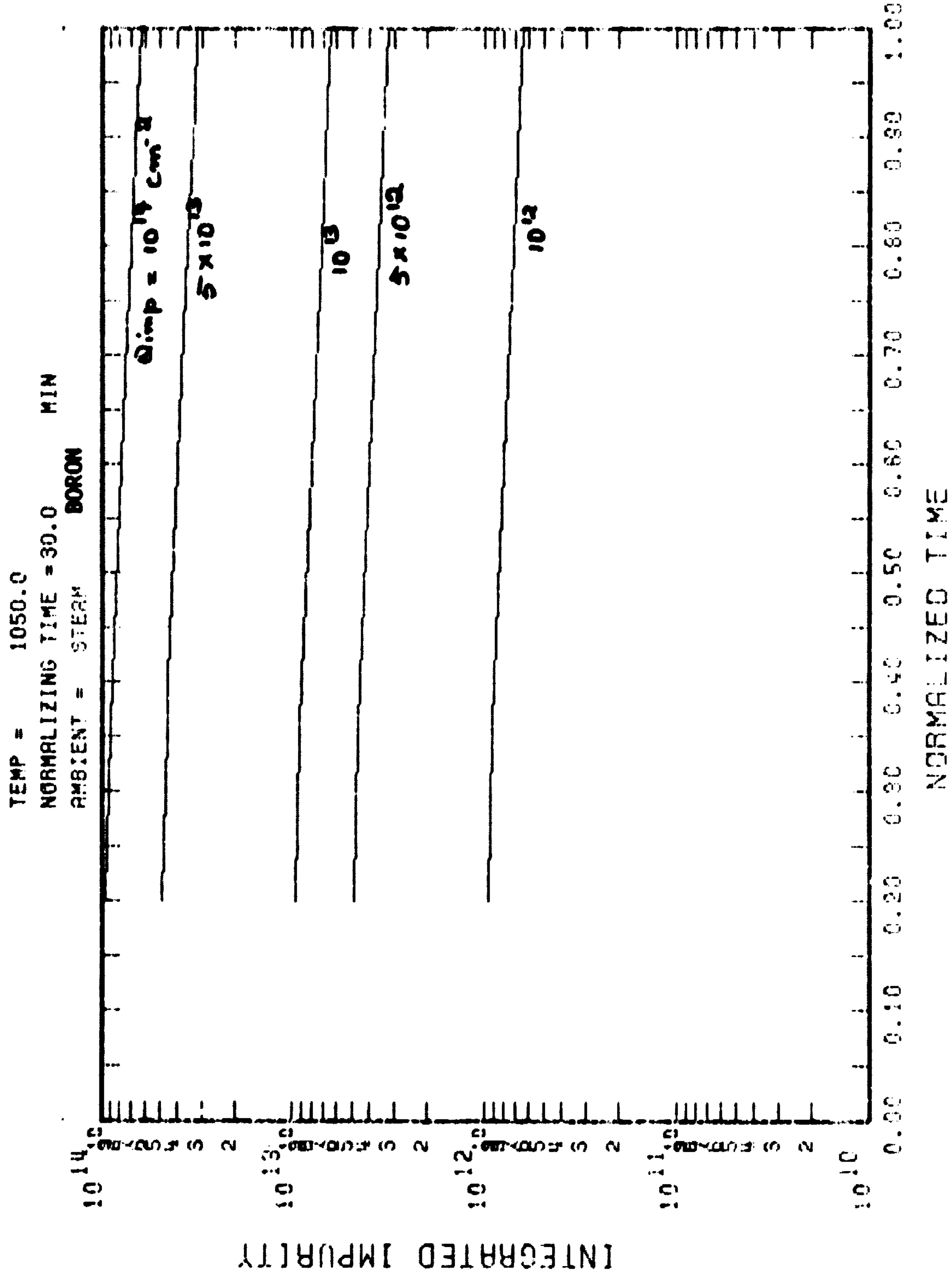


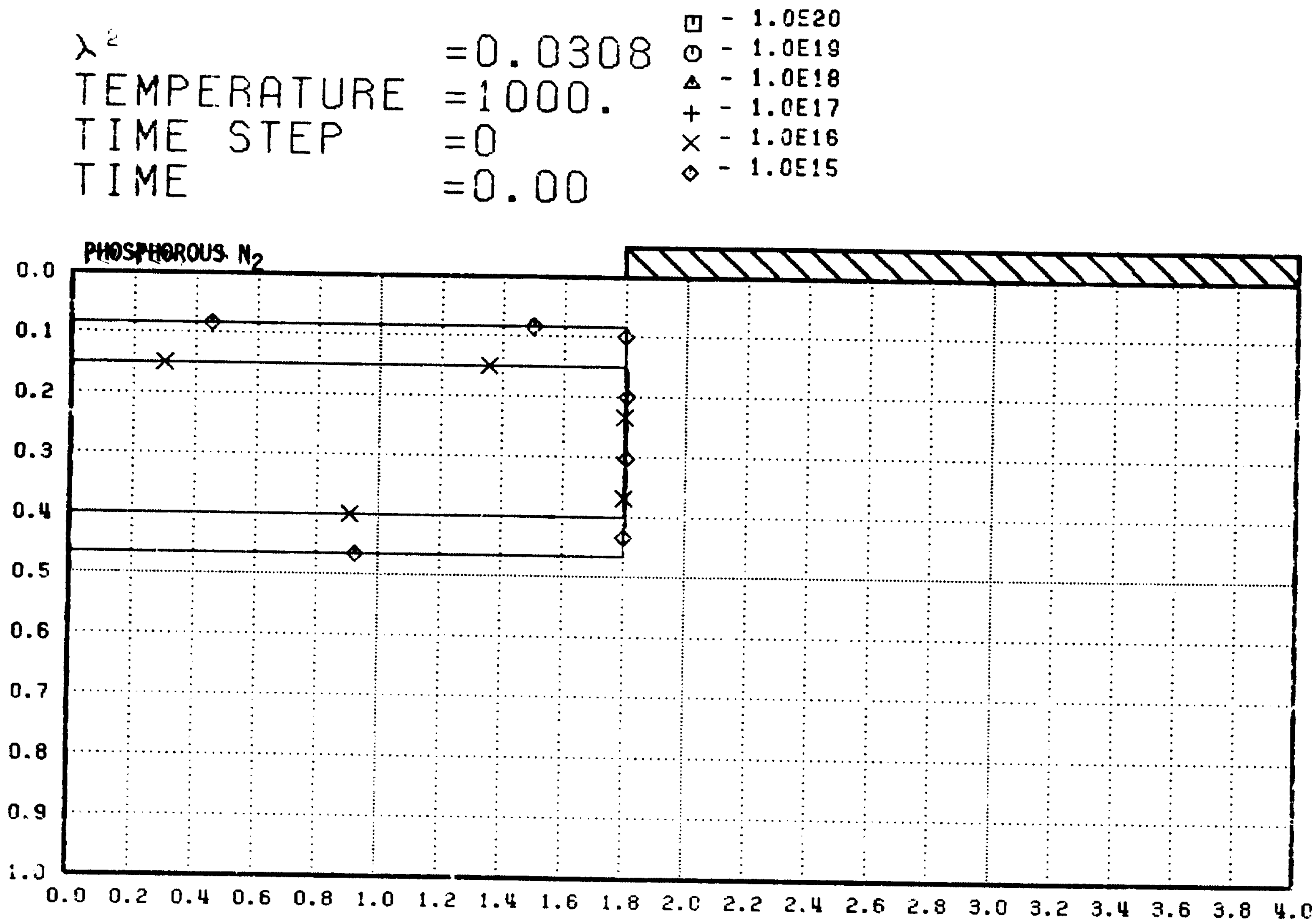

TEMP = 1050.0
NORMALIZING TIME = 30.0
AMBIENT = STEAM
BORON
THICKNESS = 0.0 CM-4
MIN
Qimp =
10^14 cm^-2
5x10^13
10^13
5x10^12
10^12
JUNCTION DEPTH
NORMALIZED TIME
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
10^-1
2
3
4
5
6
7
8
9
10^-0


TEMP = 1050.0
NORMALIZING TIME = 30.0 MIN
AMBIENT = STEAM
BORON
Qimp = 10^12 cm^-2
5x10^12
10^13
5x10^13
10^14
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
NORMALIZED TIME
10^2 10^3 10^4 10^5 10^6
SHEET RESISTANCE


TEMP = 1050.0
NORMALIZING TIME = 30.0 MIN
AMBIENT = STEAM
BORON
Qimp = 10^14 cm^-2
5x10^13
10^13
5x10^12
10^12
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
NORMALIZED TIME
10^14 10^13 10^12 10^11 10^10
INTEGRATED IMPURITY

APPENDIX

PHOSPHORUS DATA



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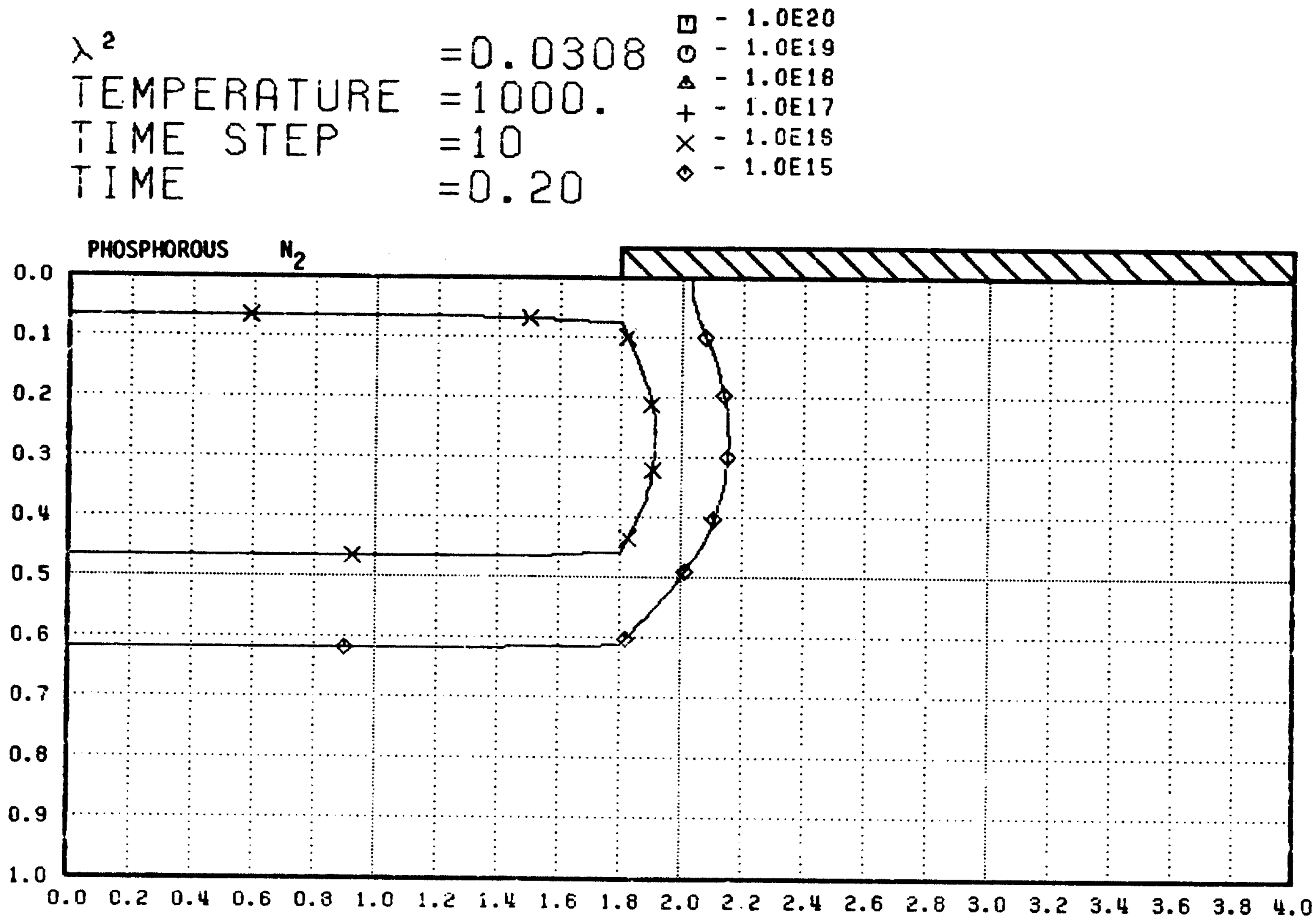

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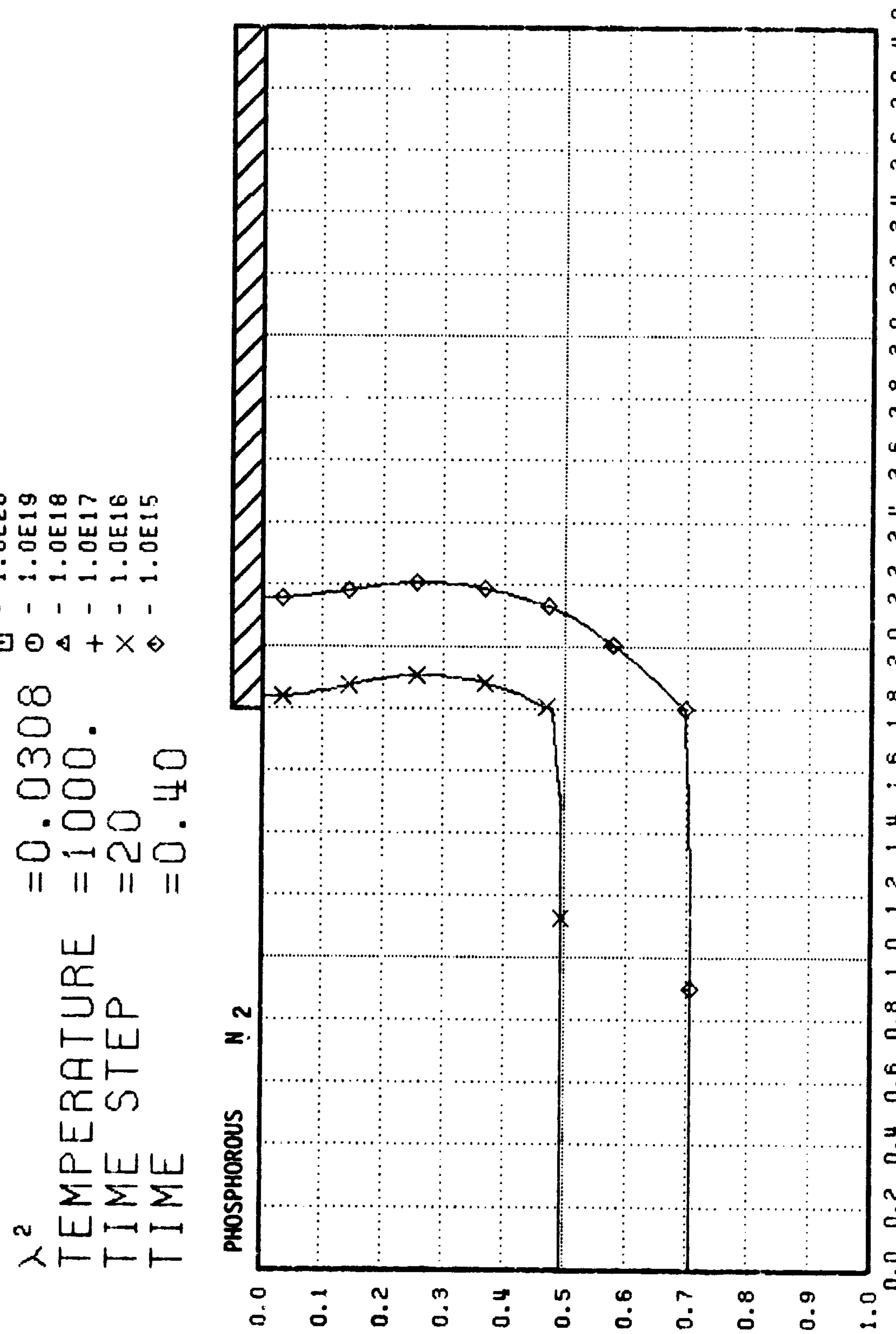

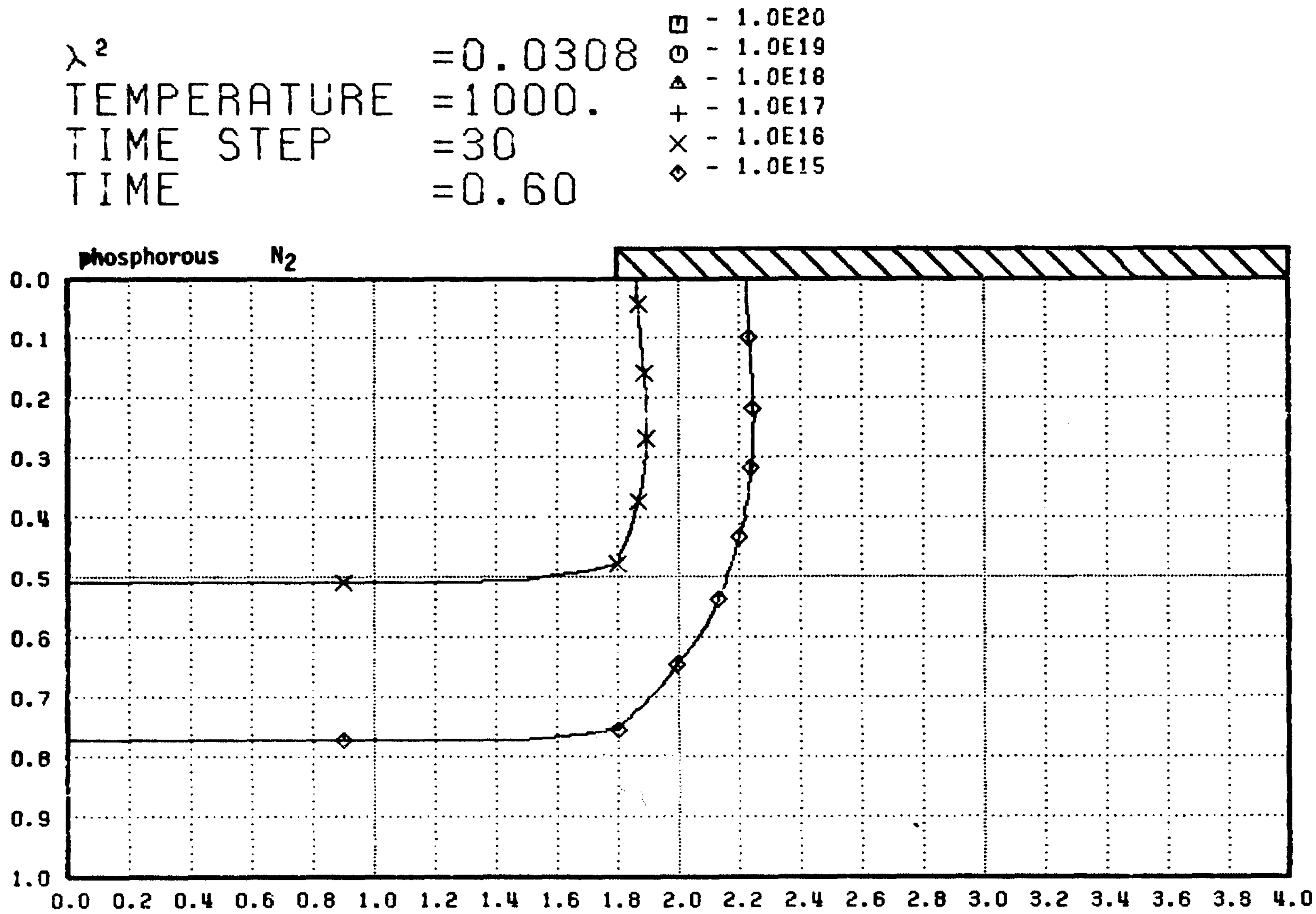

λ² =0.0308
TEMPERATURE =1000.
TIME STEP =30
TIME =0.60
□ - 1.0E20
○ - 1.0E19
△ - 1.0E18
+ - 1.0E17
× - 1.0E16
◇ - 1.0E15
phosphorous
N2
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0

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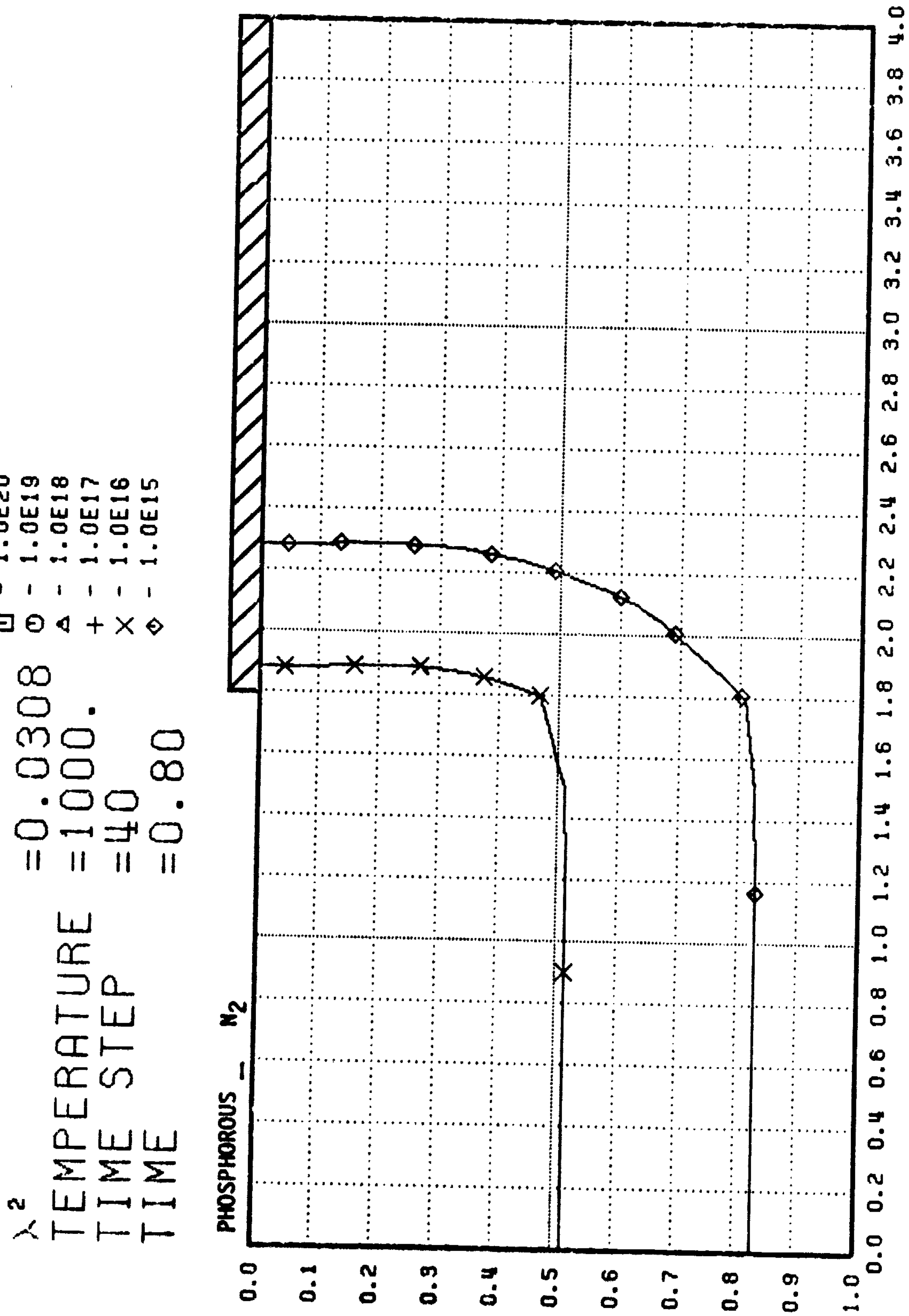
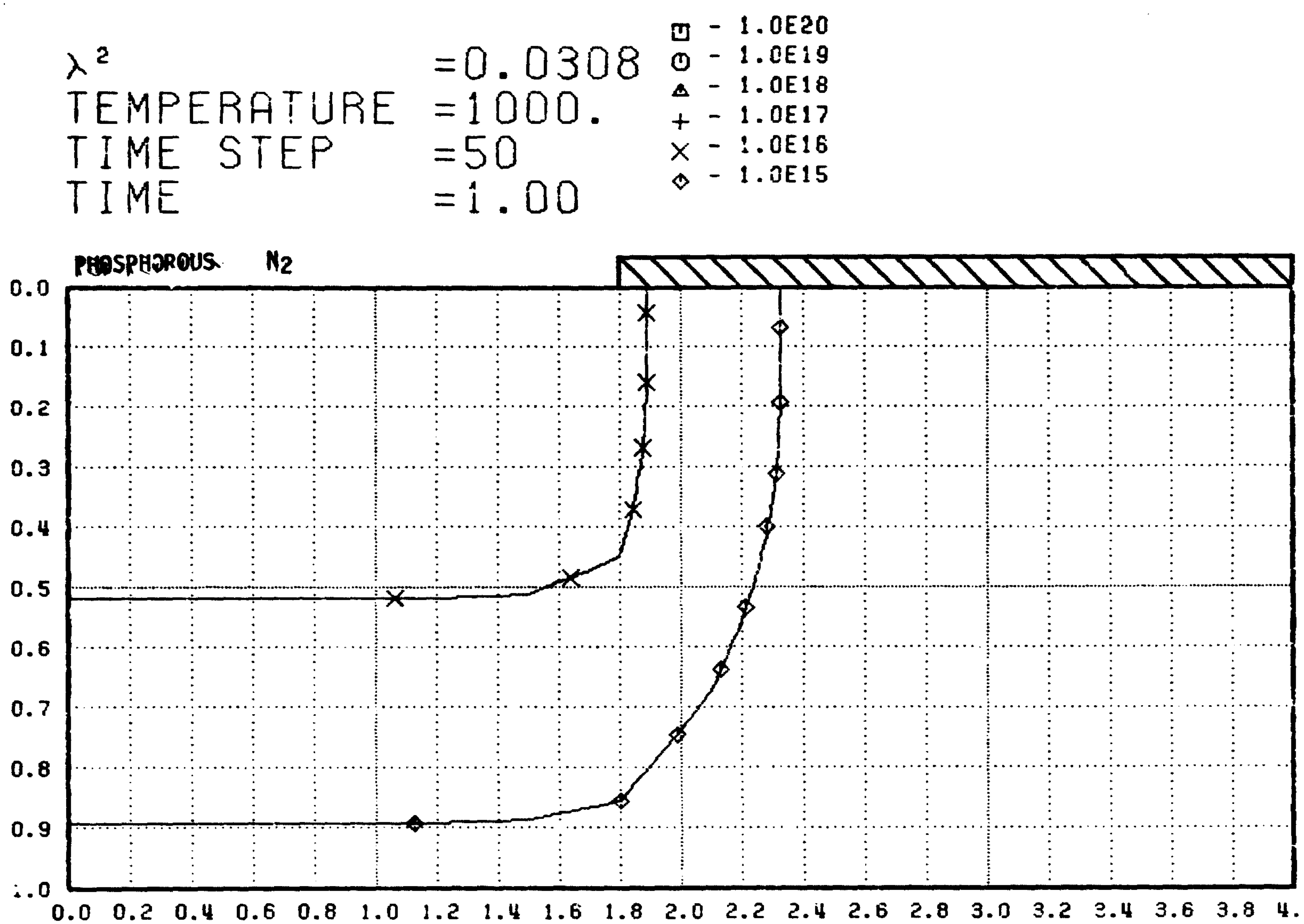
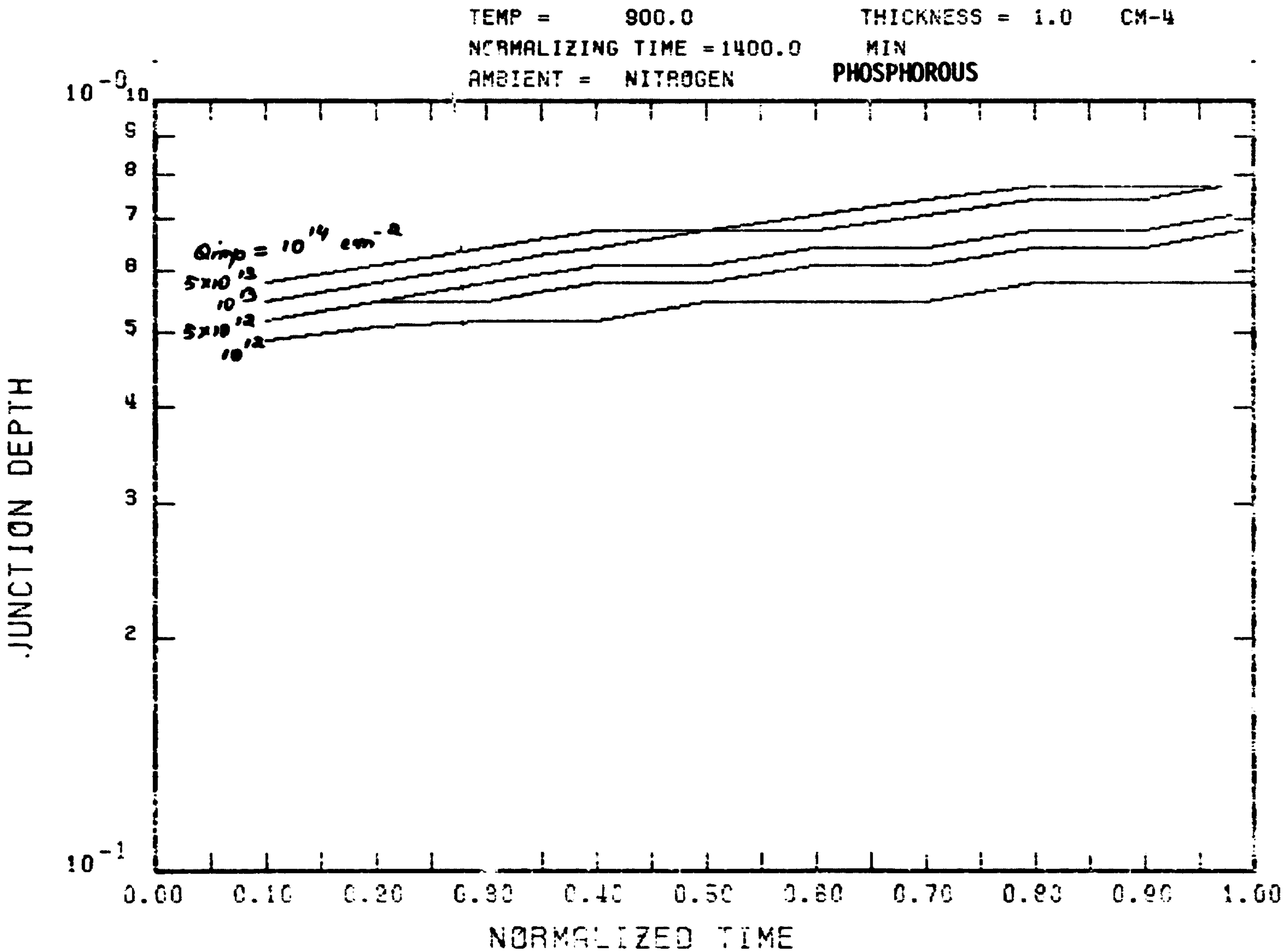




λ^2 =0.0308
TEMPERATURE =1000.
TIME STEP =50
TIME =1.00
□ - 1.0E20
O - 1.0E19
△ - 1.0E18
+ - 1.0E17
× - 1.0E16
◇ - 1.0E15
PHOSPHOROUS N2
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0



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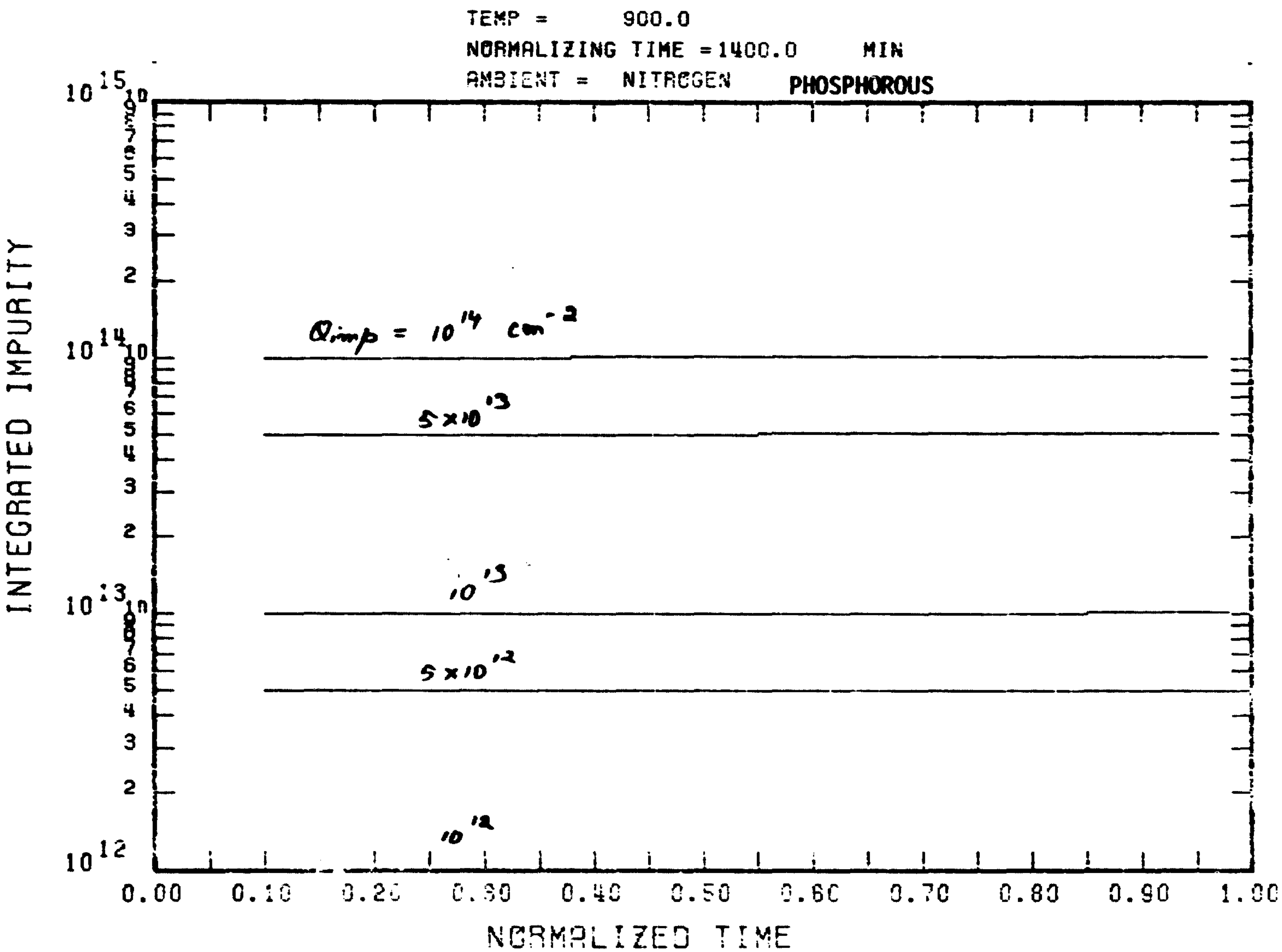
TEMP = 900.0
NORMALIZING TIME = 1400.0 MIN
AMBIENT = NITROGEN
PHOSPHOROUS
$Q_{imp} = 10^{14}\ cm^{-2}$
5×10^{13}
10^{13}
5×10^{12}
10^{12}
INTEGRATED IMPURITY
NORMALIZED TIME
10^{15}
10^{14}
10^{13}
10^{12}
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

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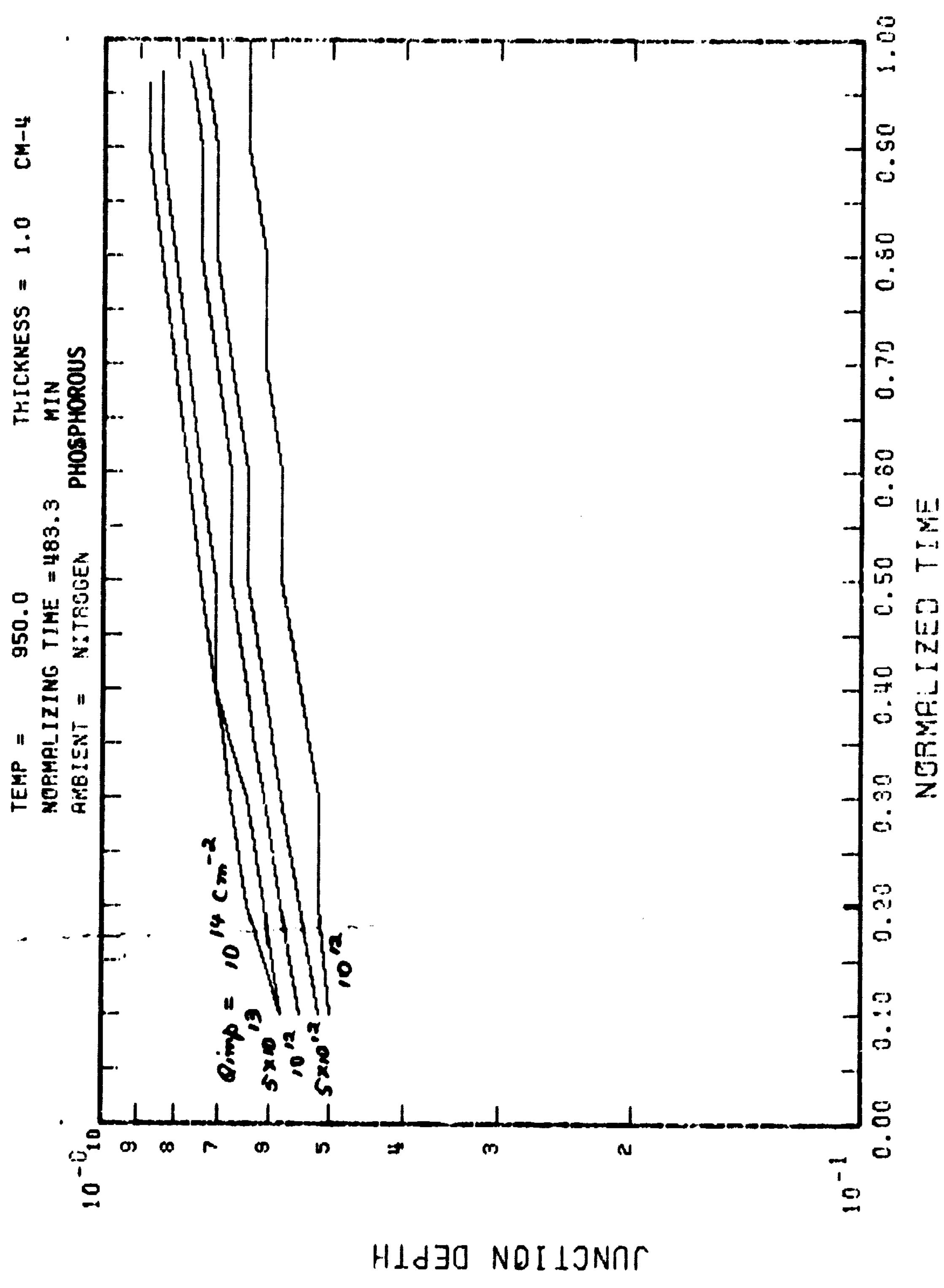

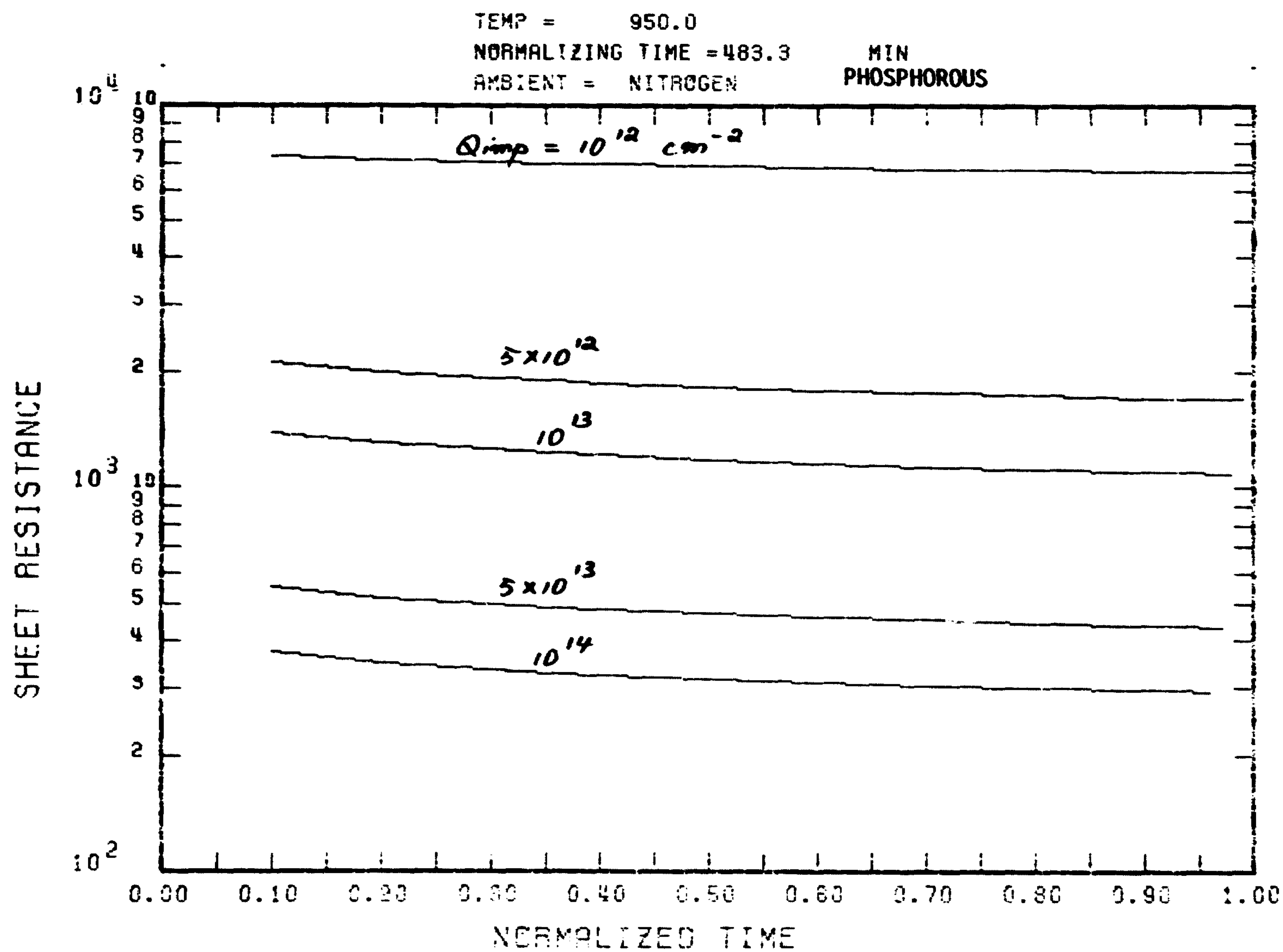
TEMP = 950.0
NORMALIZING TIME =483.3 MIN
AMBIENT = NITROGEN
PHOSPHOROUS
Qimp = 10^12 cm^-2
5x10^12
10^13
5x10^13
10^14
SHEET RESISTANCE
NORMALIZED TIME

ORIGINAL PAGE IS
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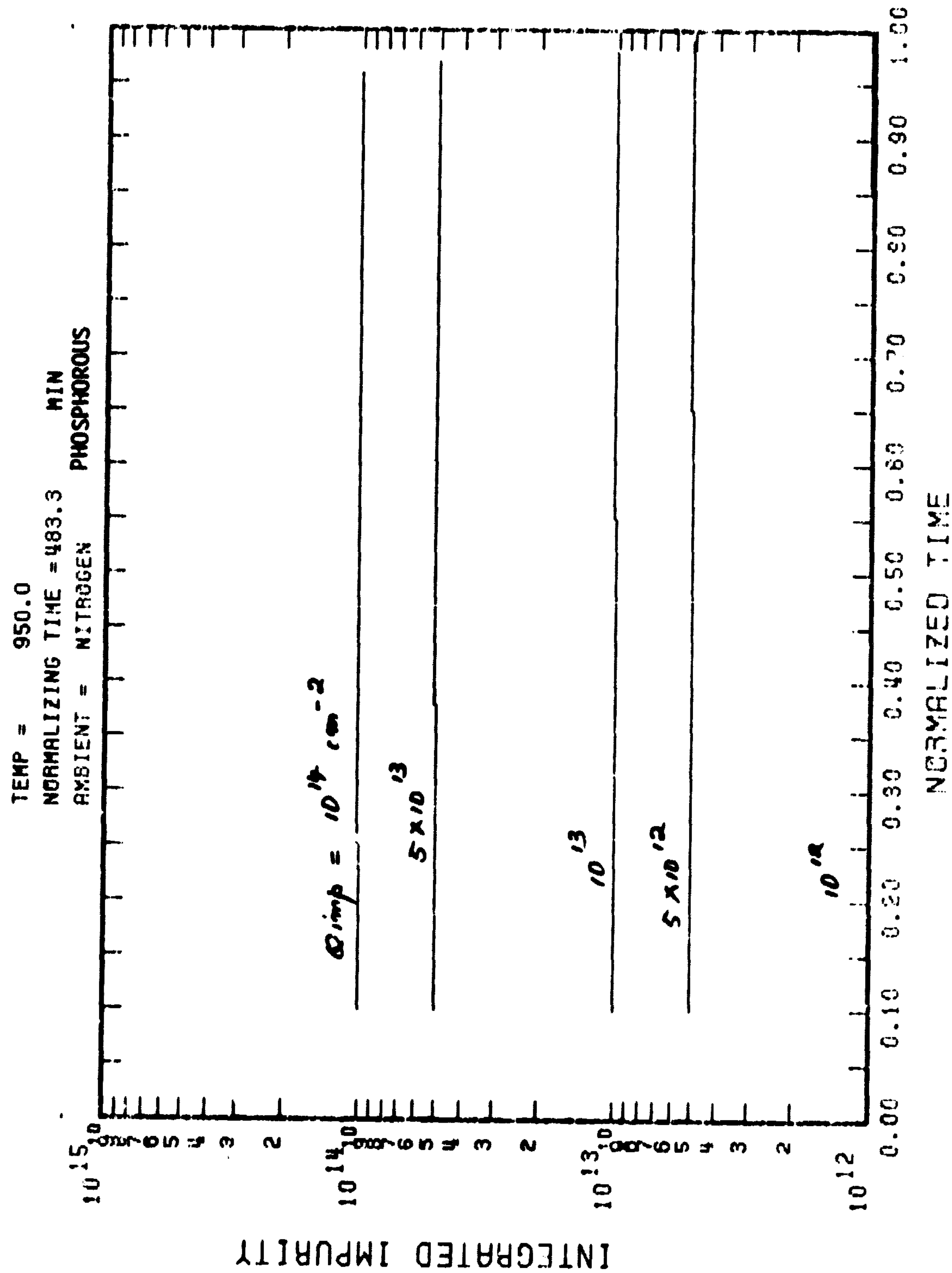
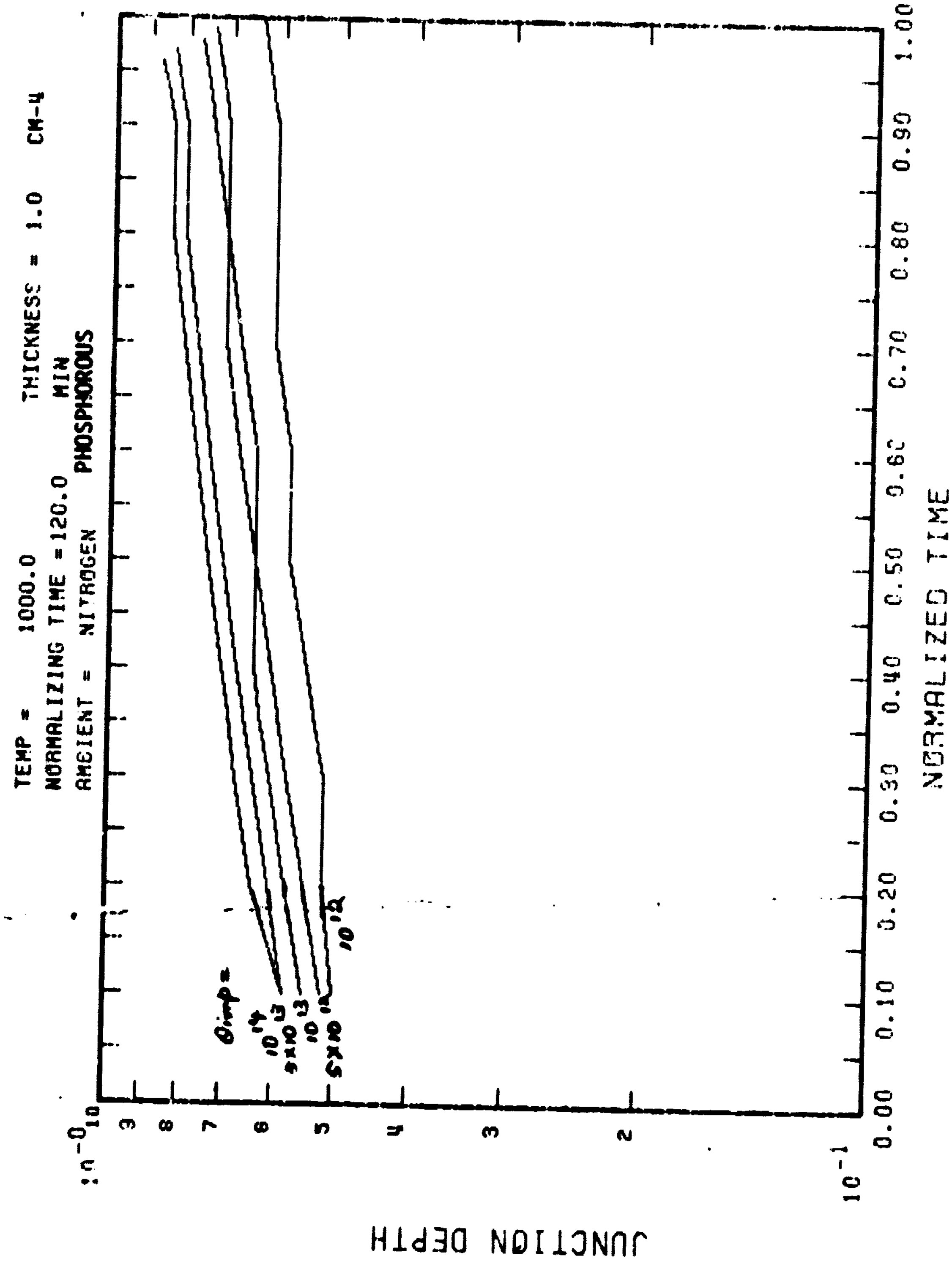
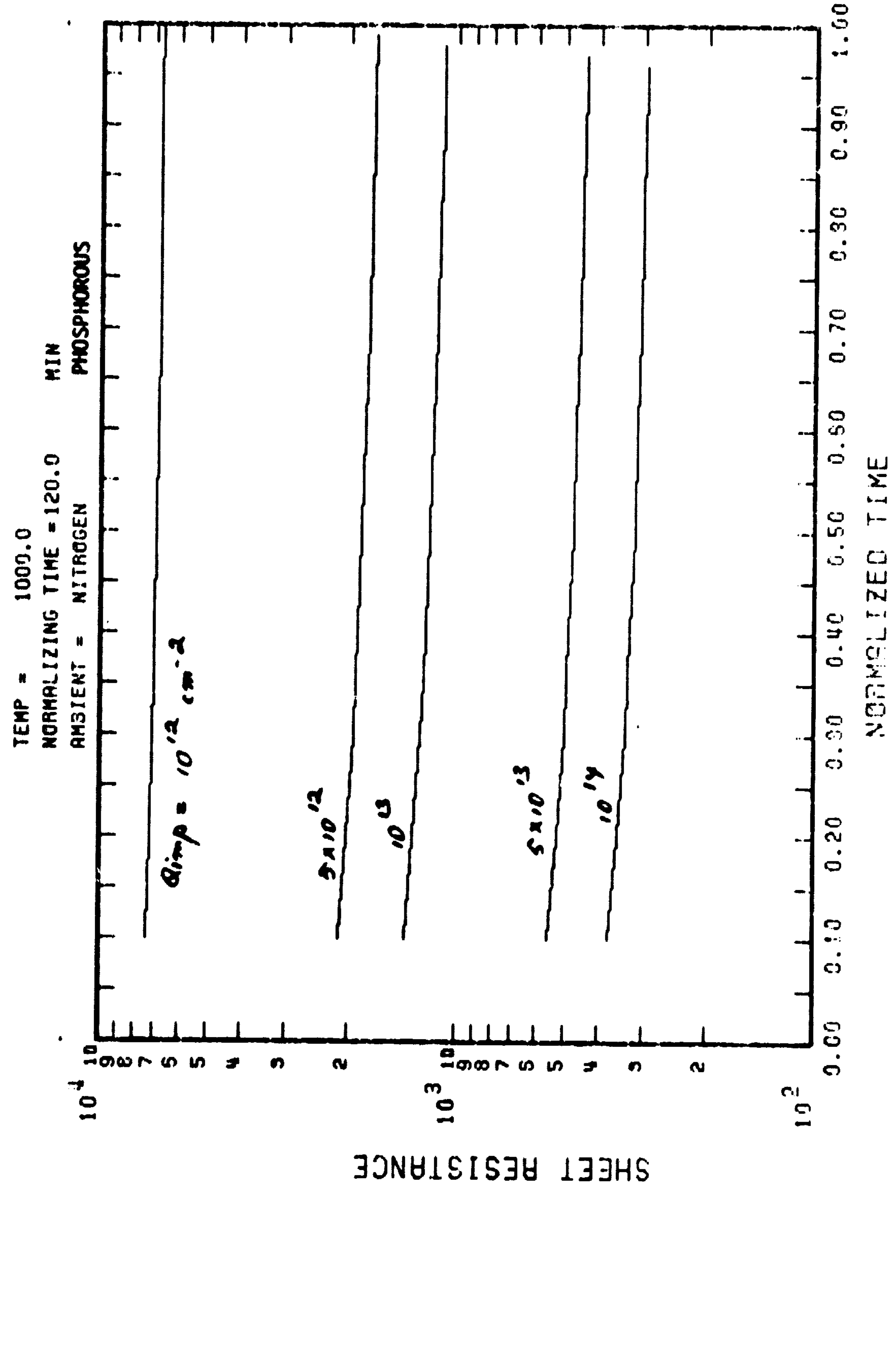
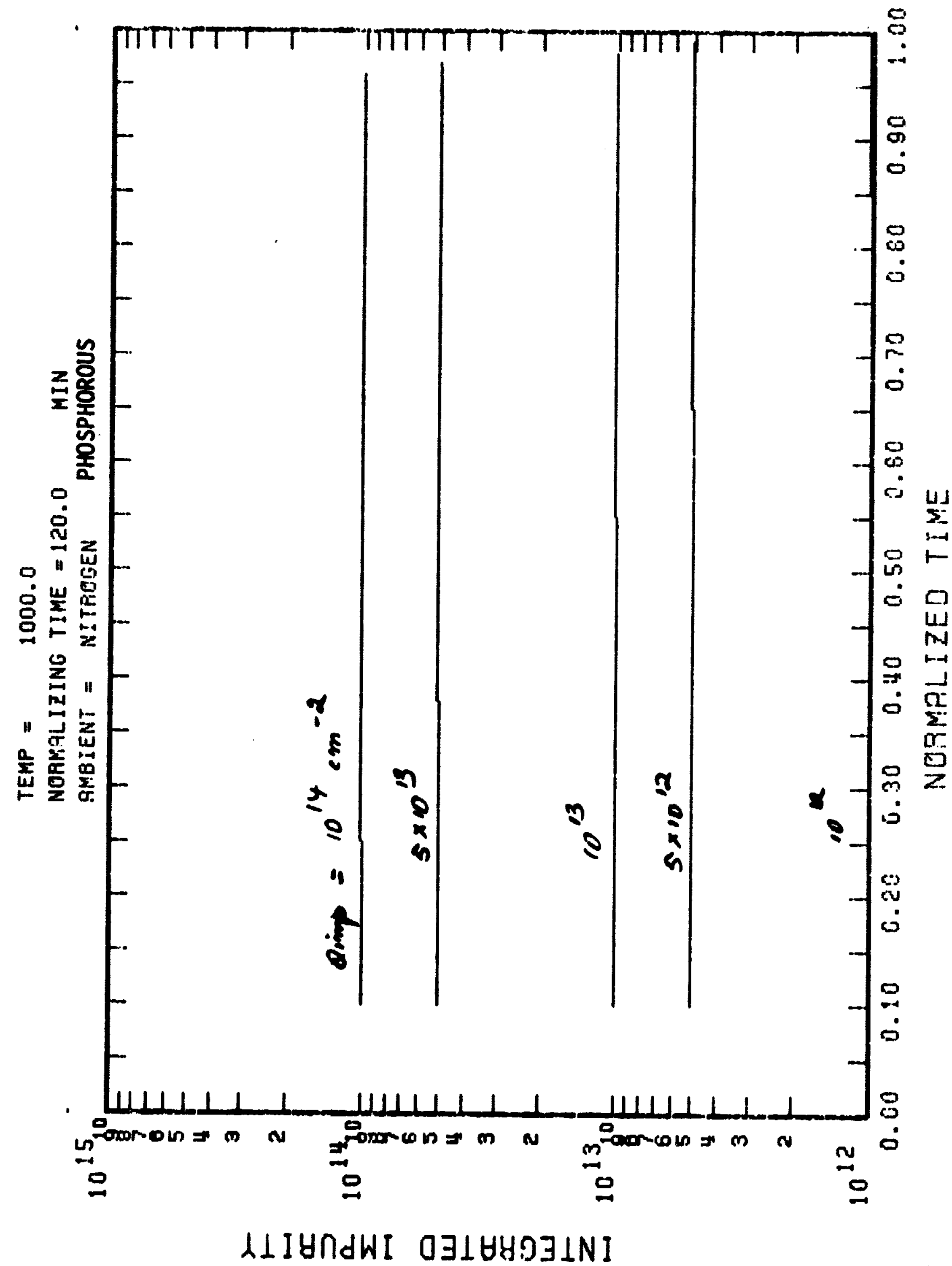


C-2


TEMP = 1000.0 THICKNESS = 1.0 CM-4
NORMALIZING TIME = 120.0 MIN
AMBIENT = NITROGEN PHOSPHOROUS
Q_{imp} =
10^{14}
5×10^{13}
10^{13}
5×10^{12}
10^{12}
JUNCTION DEPTH
10^{0}
10^{-1}
NORMALIZED TIME
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


TEMP = 1000.0
NORMALIZING TIME = 120.0 MIN
AMBIENT = NITROGEN
PHOSPHOROUS
Qimp = 10^12 cm^-2
5x10^12
10^13
5x10^13
10^14
SHEET RESISTANCE
NORMALIZED TIME


TEMP = 1000.0
NORMALIZING TIME = 120.0 MIN
AMBIENT = NITROGEN PHOSPHOROUS
Qimp = 10^14 cm^-2
5x10^13
10^13
5x10^12
10^12
NORMALIZED TIME
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
INTEGRATED IMPURITY
10^15
10^14
10^13
10^12

C-2

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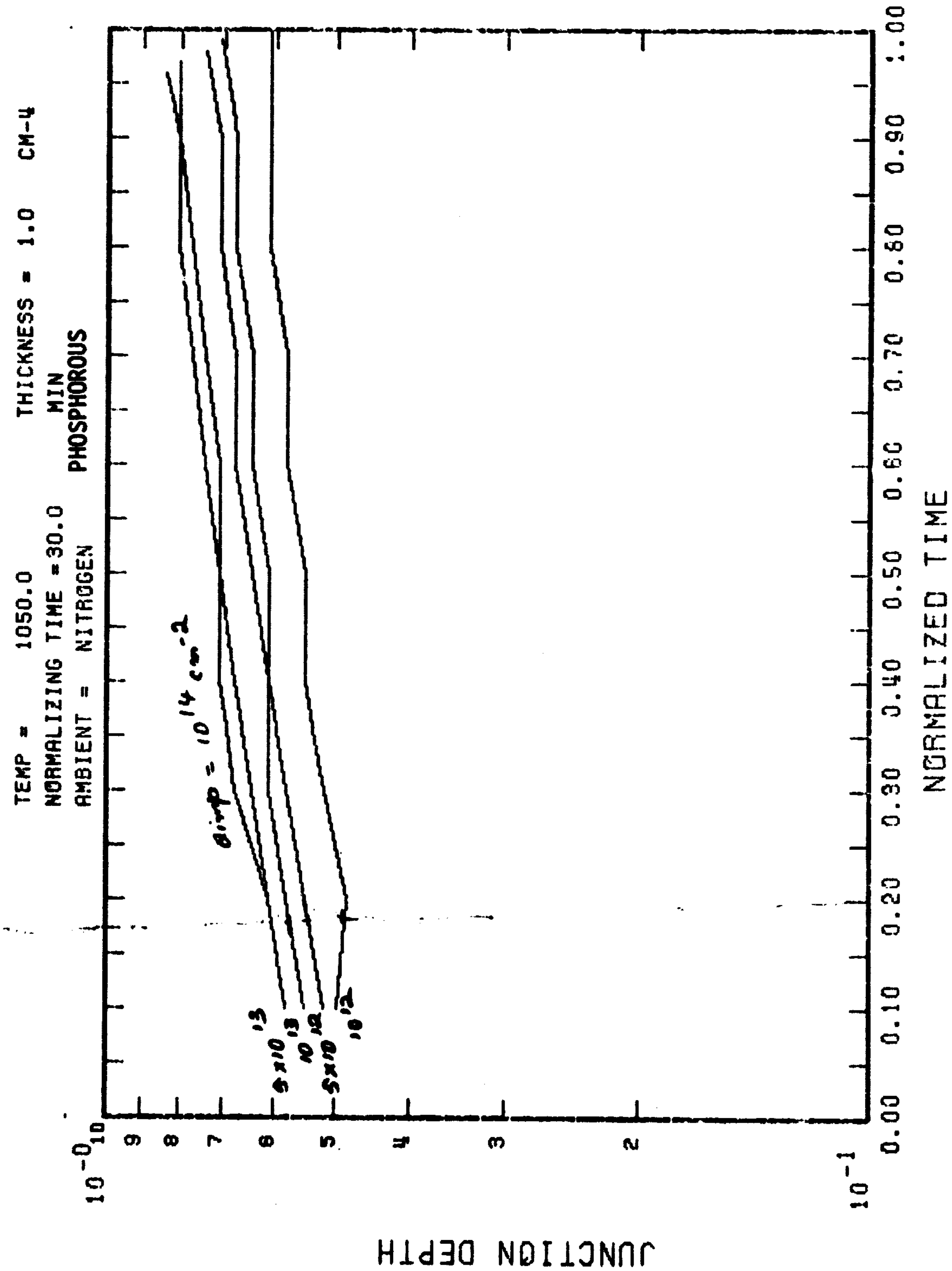

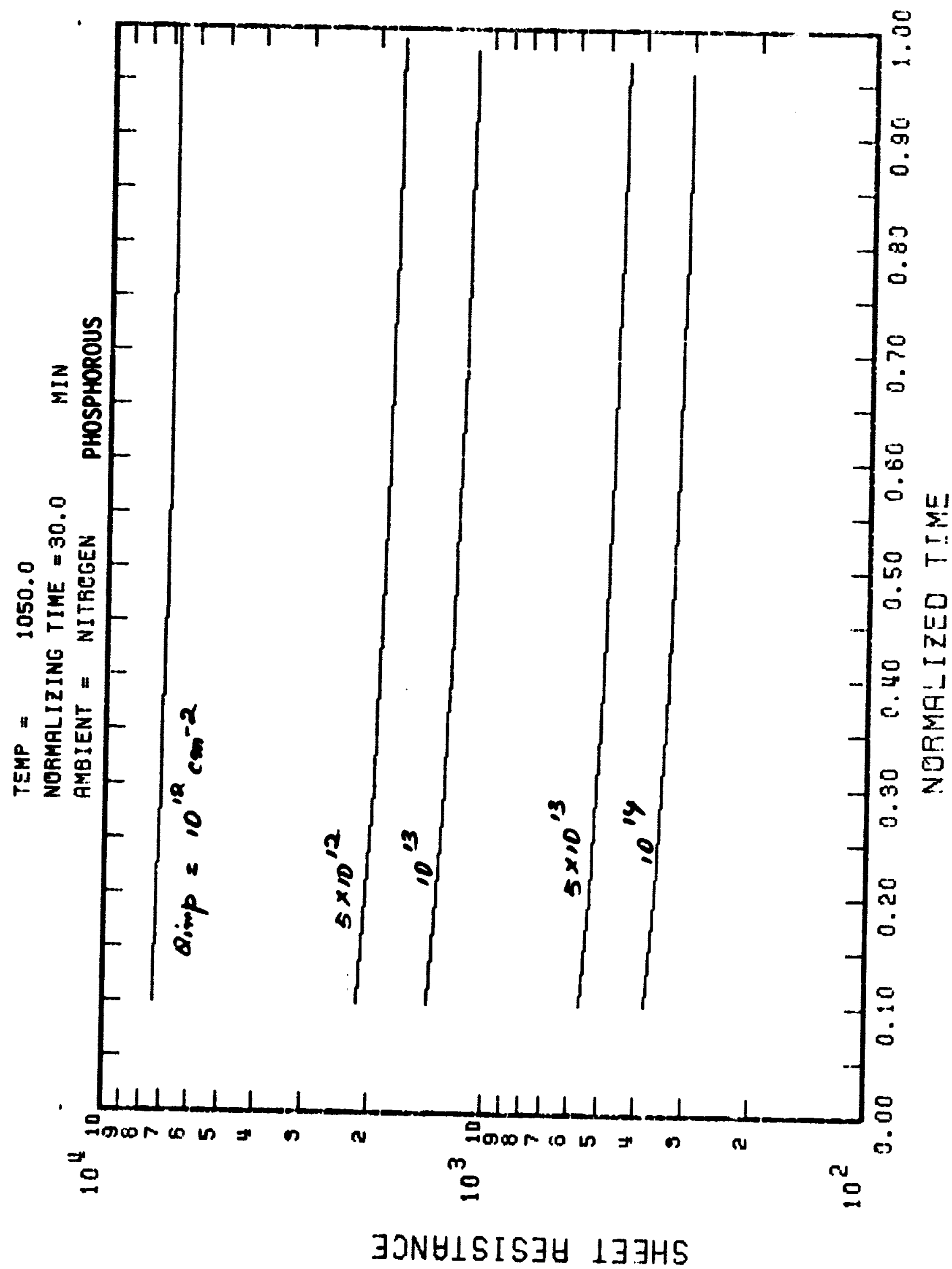
TEMP = 1050.0
NORMALIZING TIME = 30.0 MIN
AMBIENT = NITROGEN
PHOSPHOROUS
Qimp = 10^12 cm^-2
5x10^12
10^13
5x10^13
10^14
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
NORMALIZED TIME
10^2
10^3
10^4
SHEET RESISTANCE

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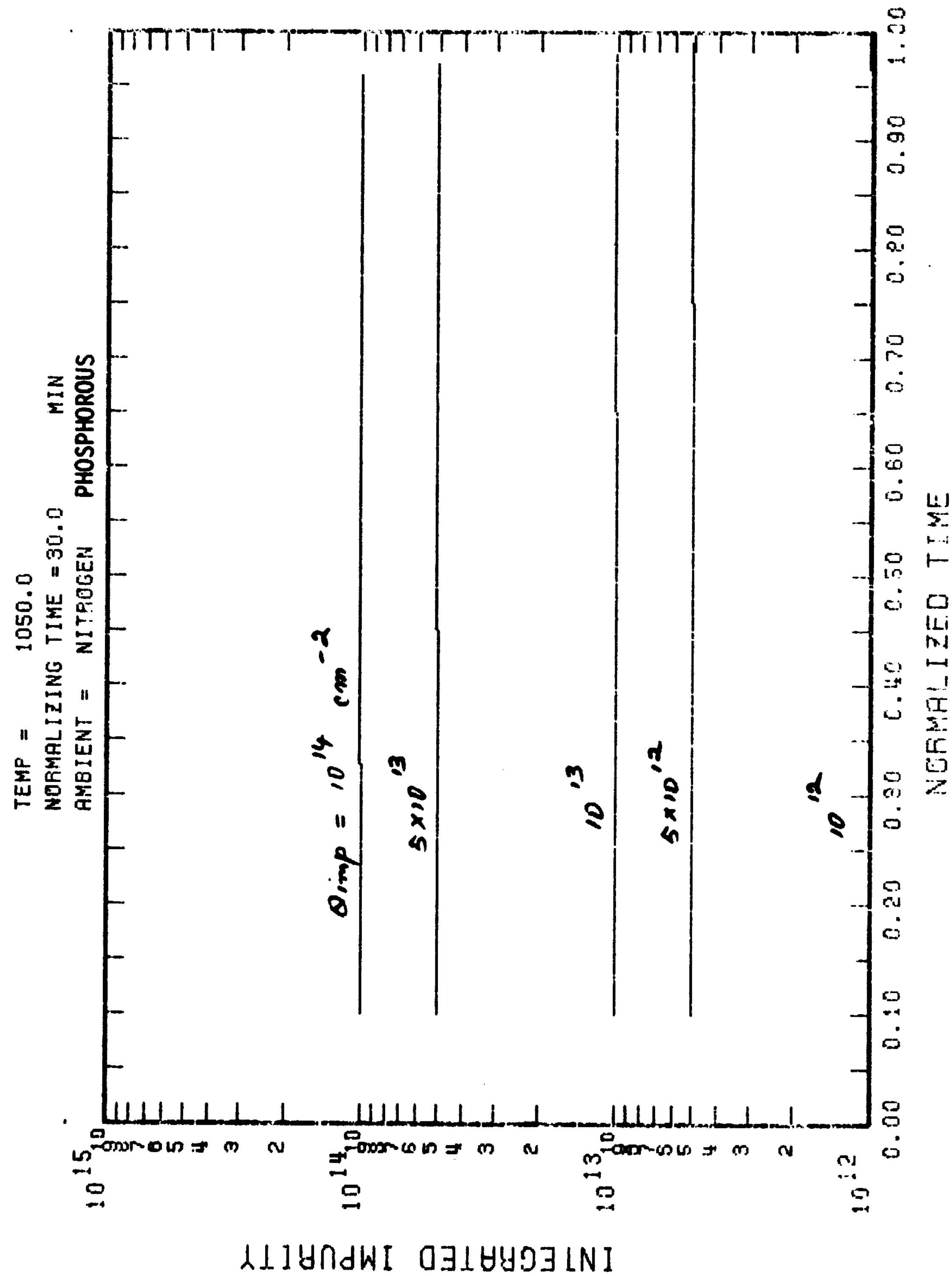

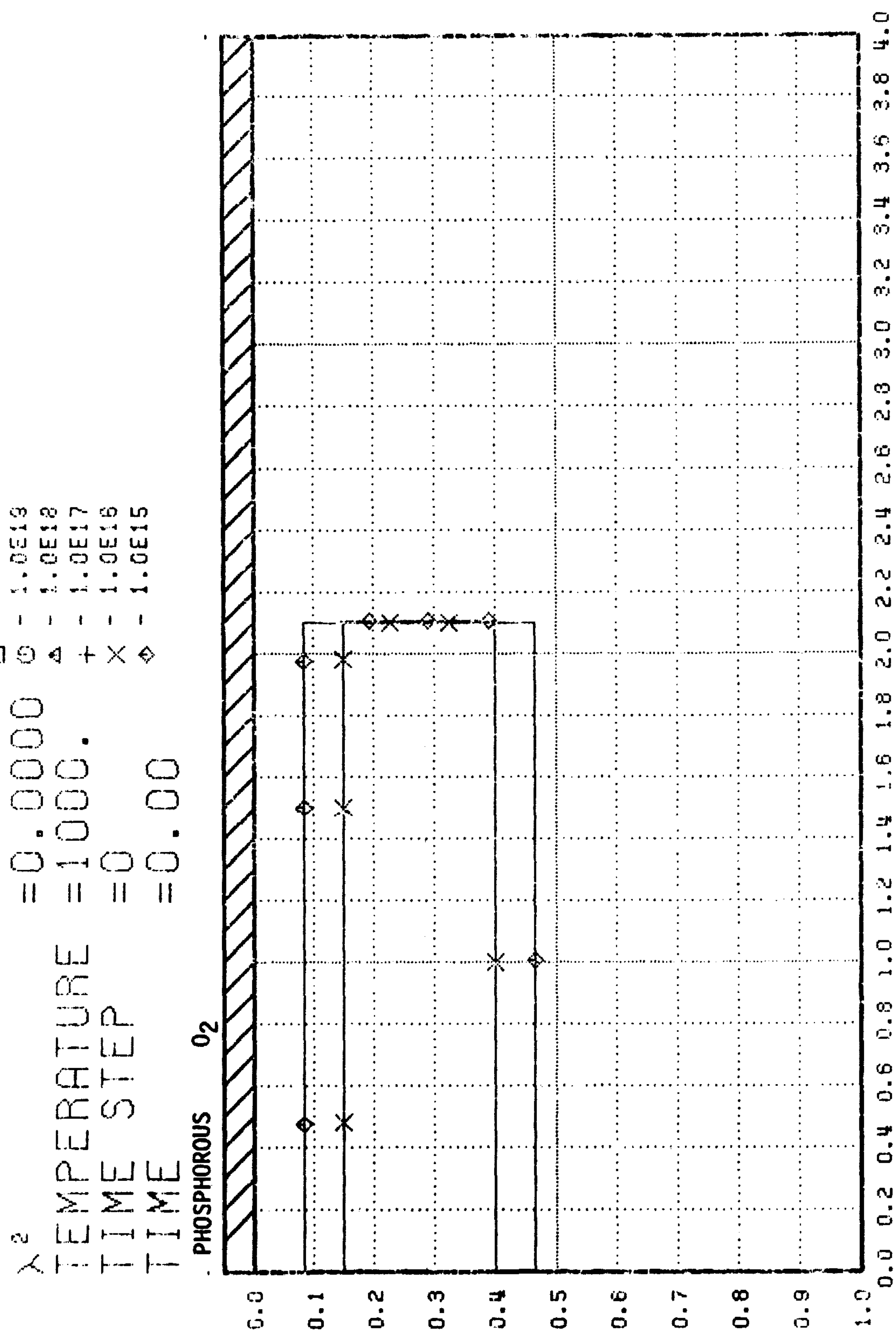
λ² =0.0000
TEMPERATURE =1000.
TIME STEP =0
TIME =0.00
⊟ - 1.0E20
⊙ - 1.0E19
△ - 1.0E18
+ - 1.0E17
× - 1.0E16
◇ - 1.0E15
PHOSPHOROUS
O2
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0

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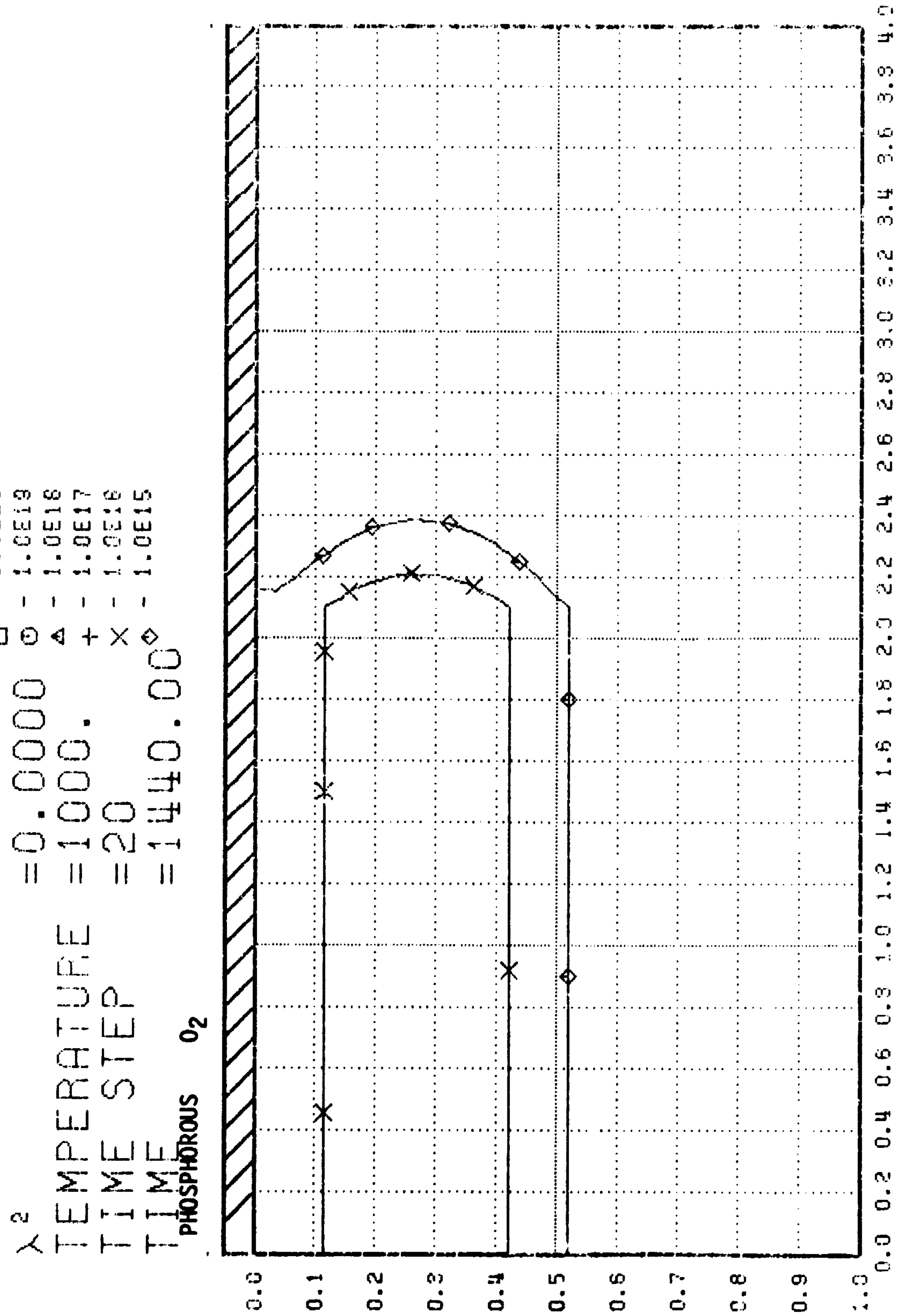

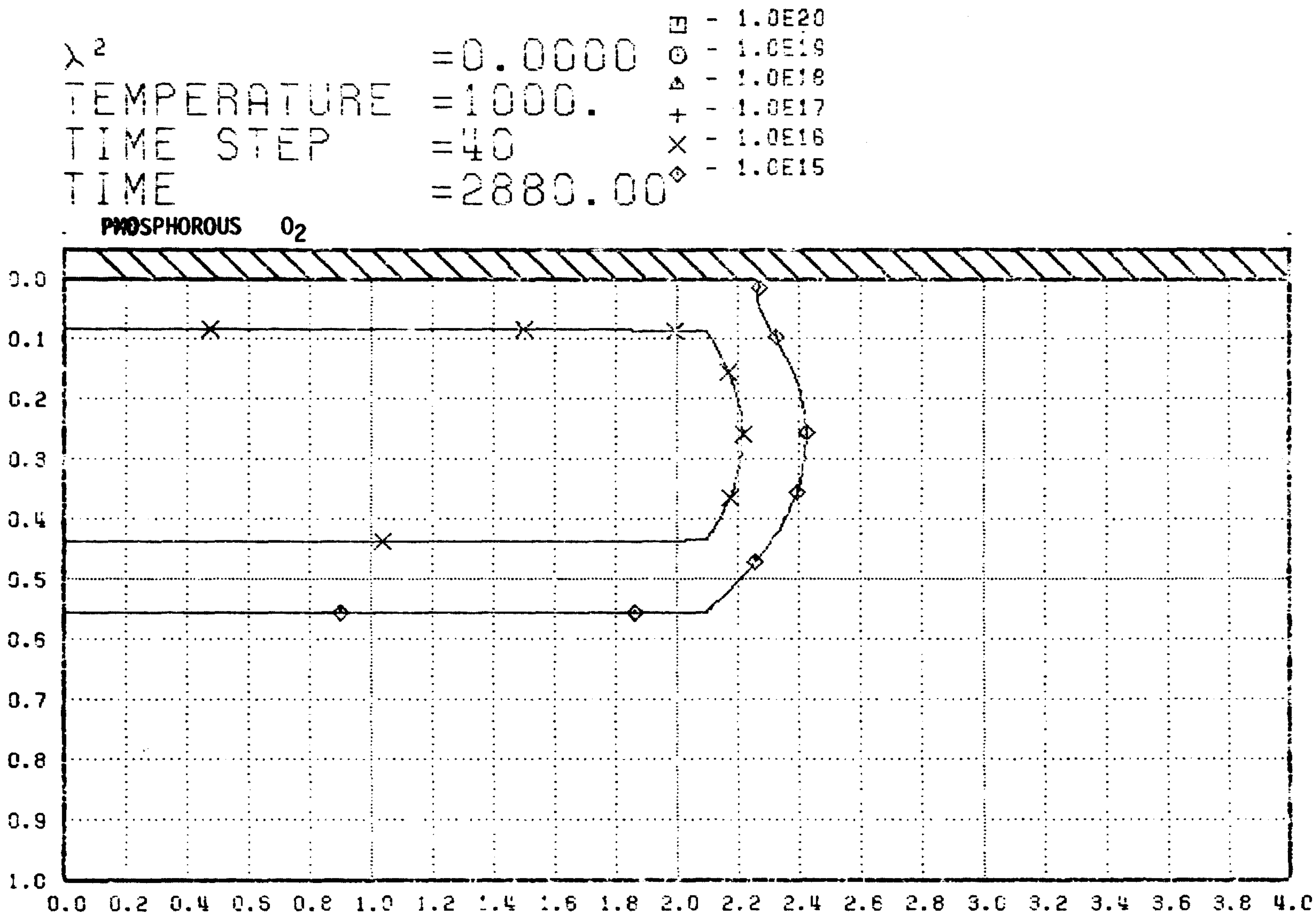

λ 2 =0.0000
TEMPERATURE =1000.
TIME STEP =40
TIME =2880.00
⊞ - 1.0E20
⊙ - 1.0E19
△ - 1.0E18
+ - 1.0E17
× - 1.0E16
◇ - 1.0E15
PHOSPHOROUS
O2
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0

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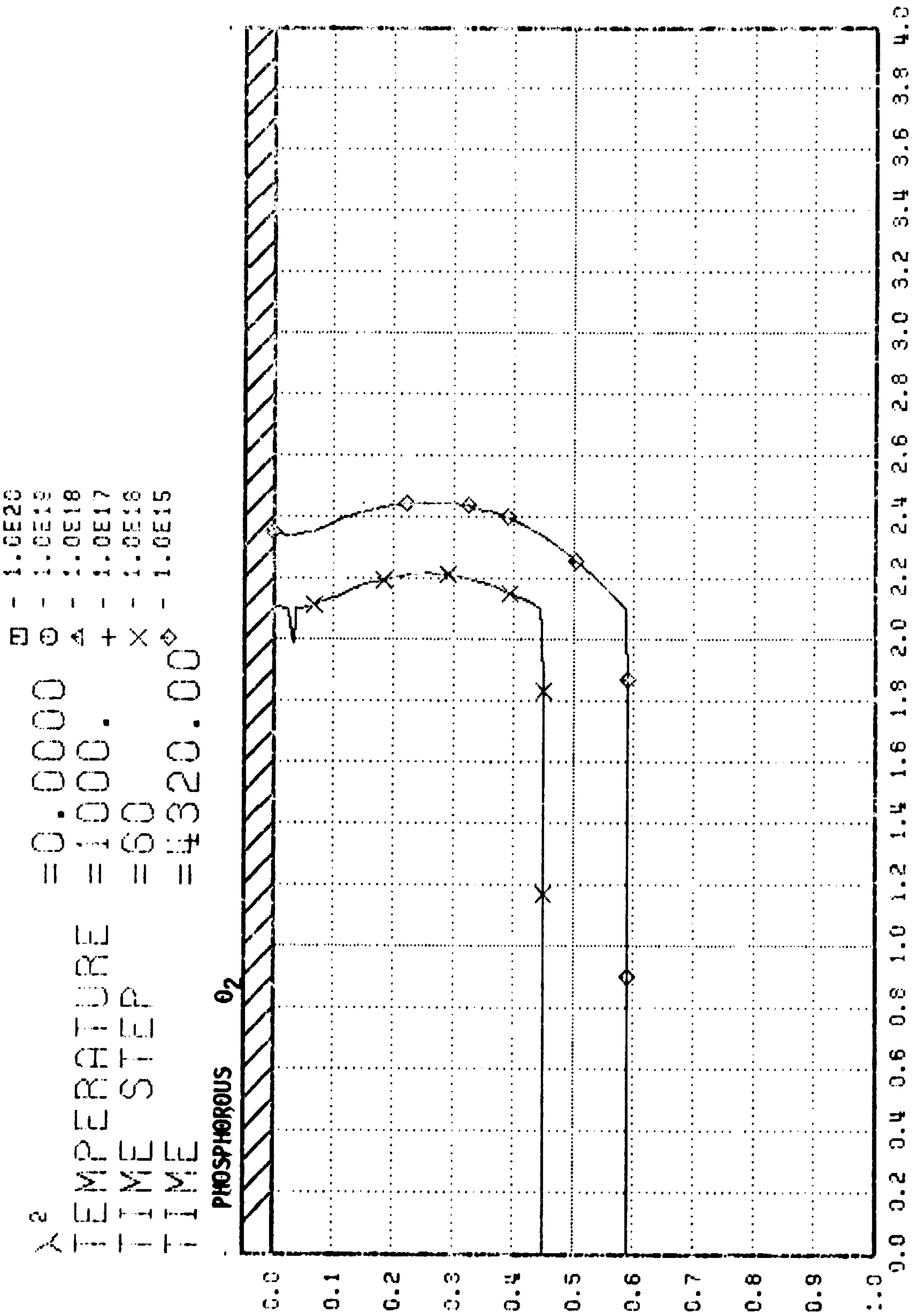
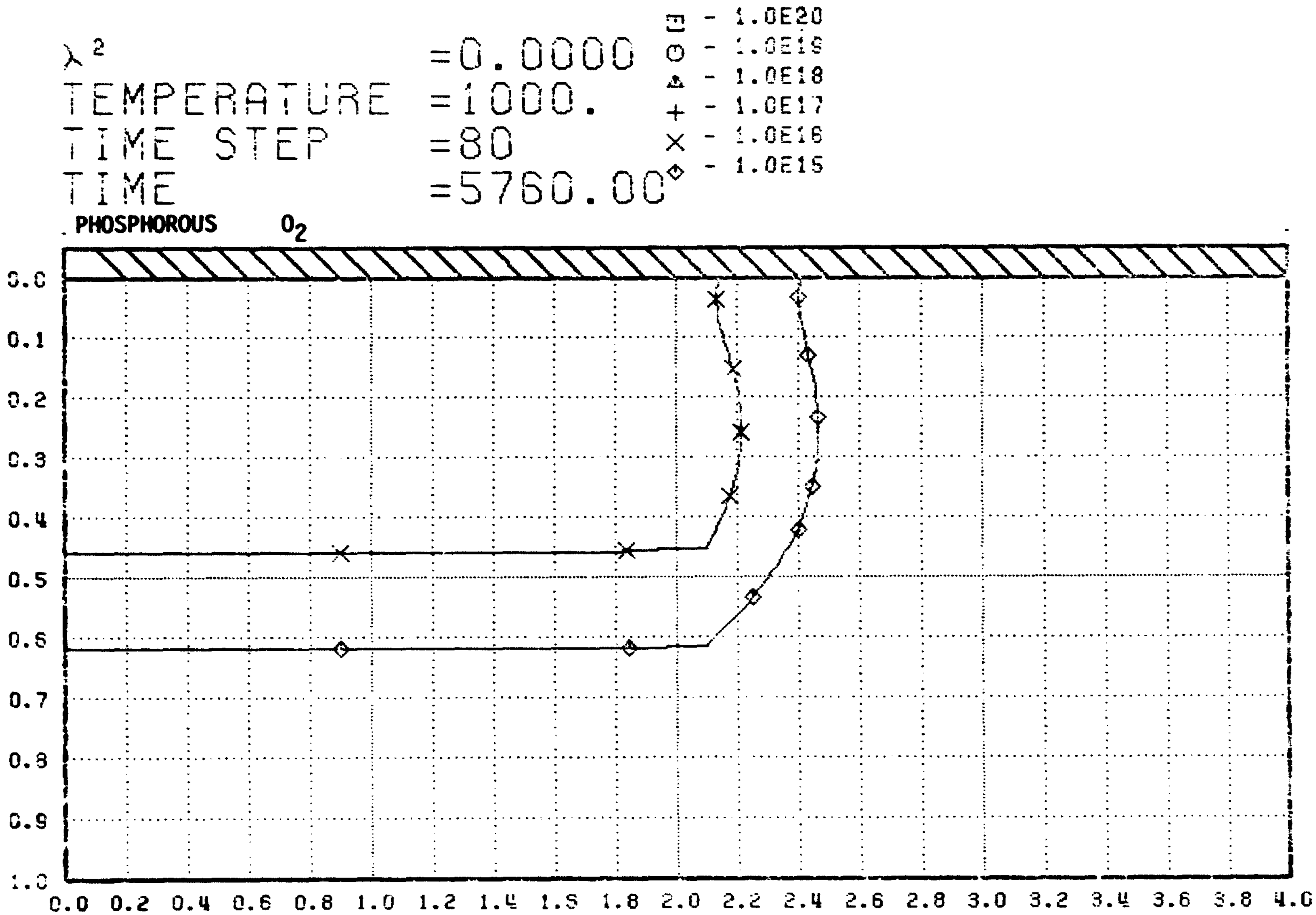
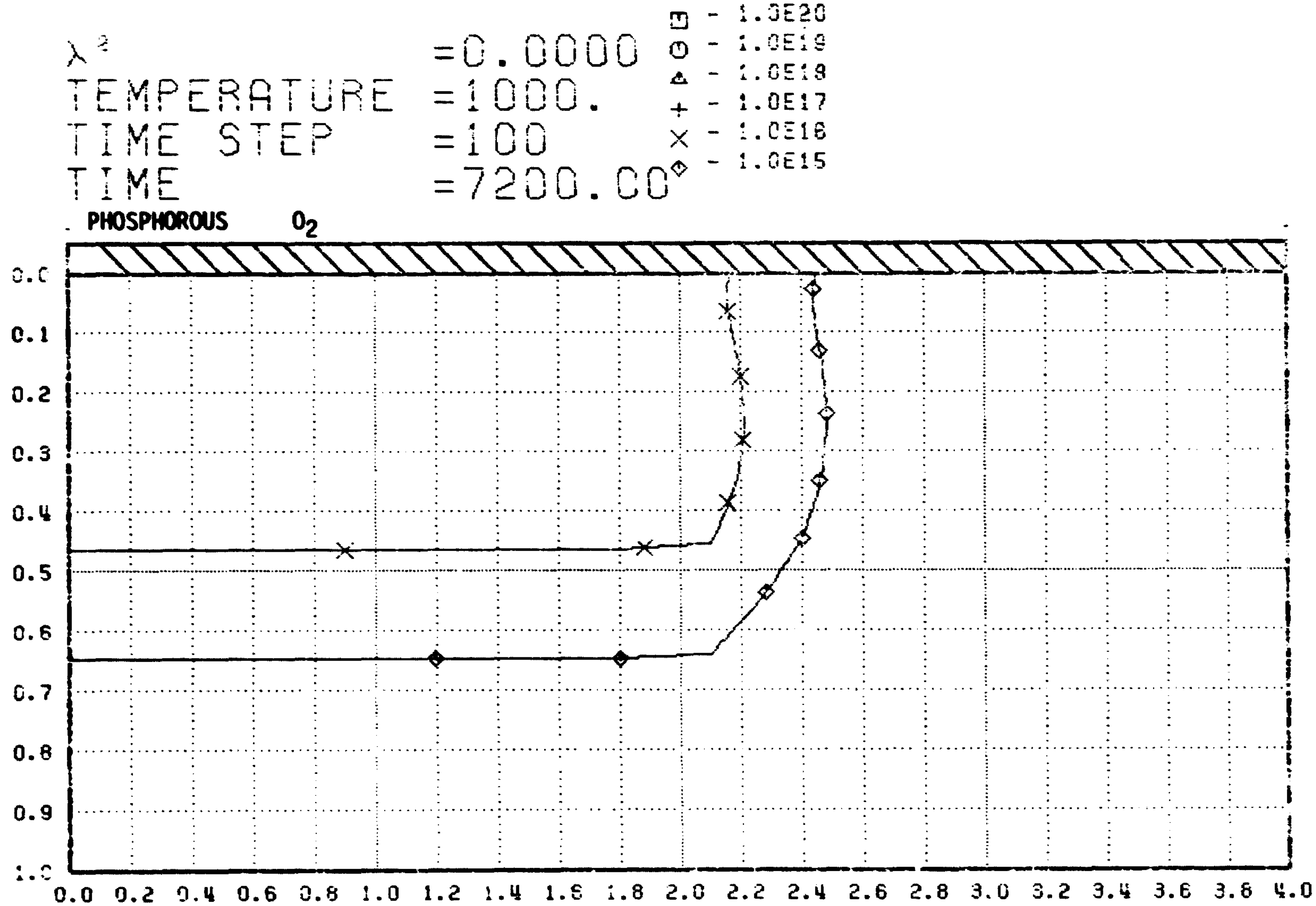




λ^2 =0.0000
TEMPERATURE =1000.
TIME STEP =80
TIME =5760.00
□ - 1.0E20
○ - 1.0E19
△ - 1.0E18
+ - 1.0E17
× - 1.0E16
◇ - 1.0E15
PHOSPHOROUS
O_2
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0

λ^2 =0.0000
TEMPERATURE =1000.
TIME STEP =100
TIME =7200.00



B 24

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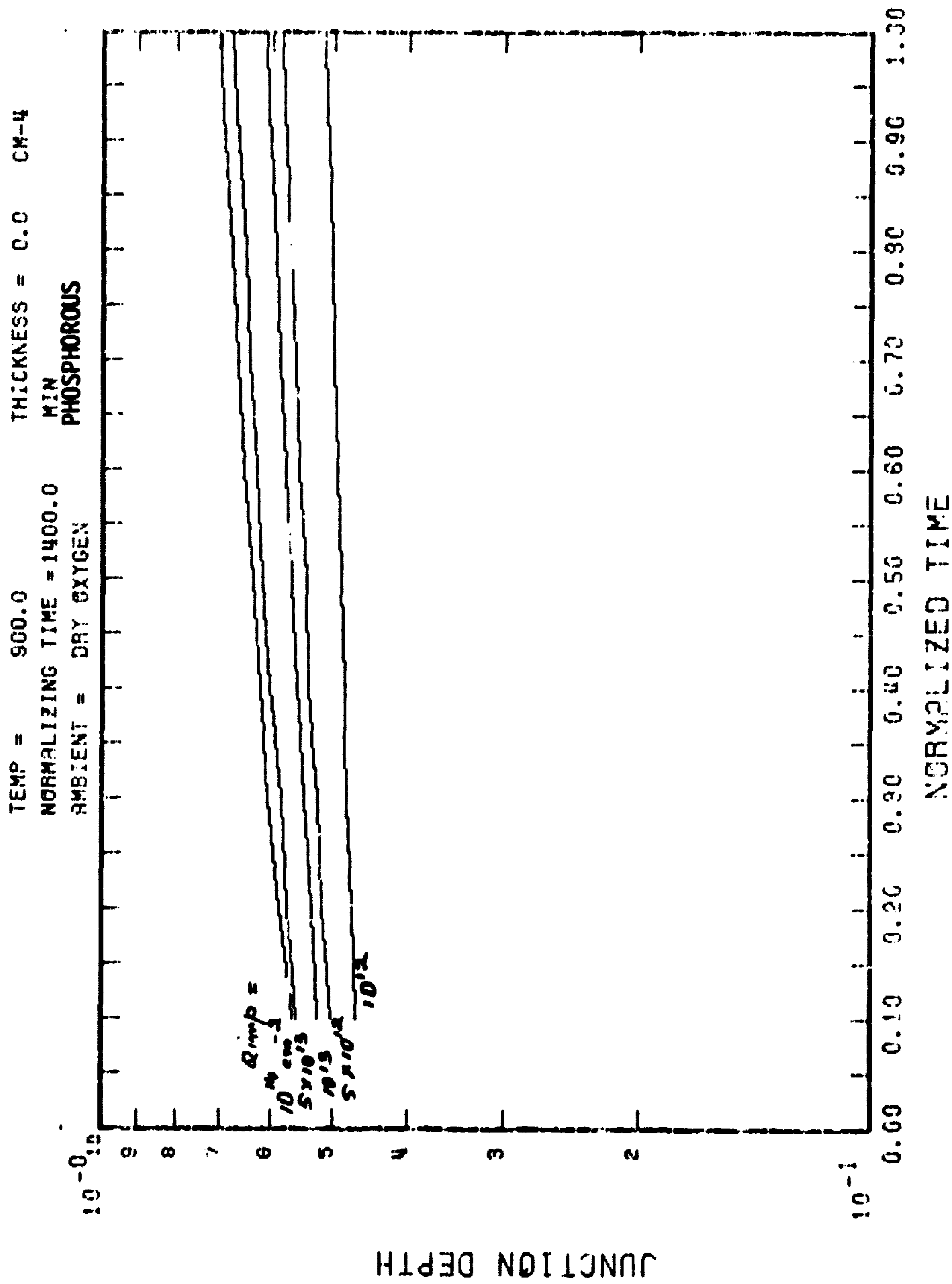
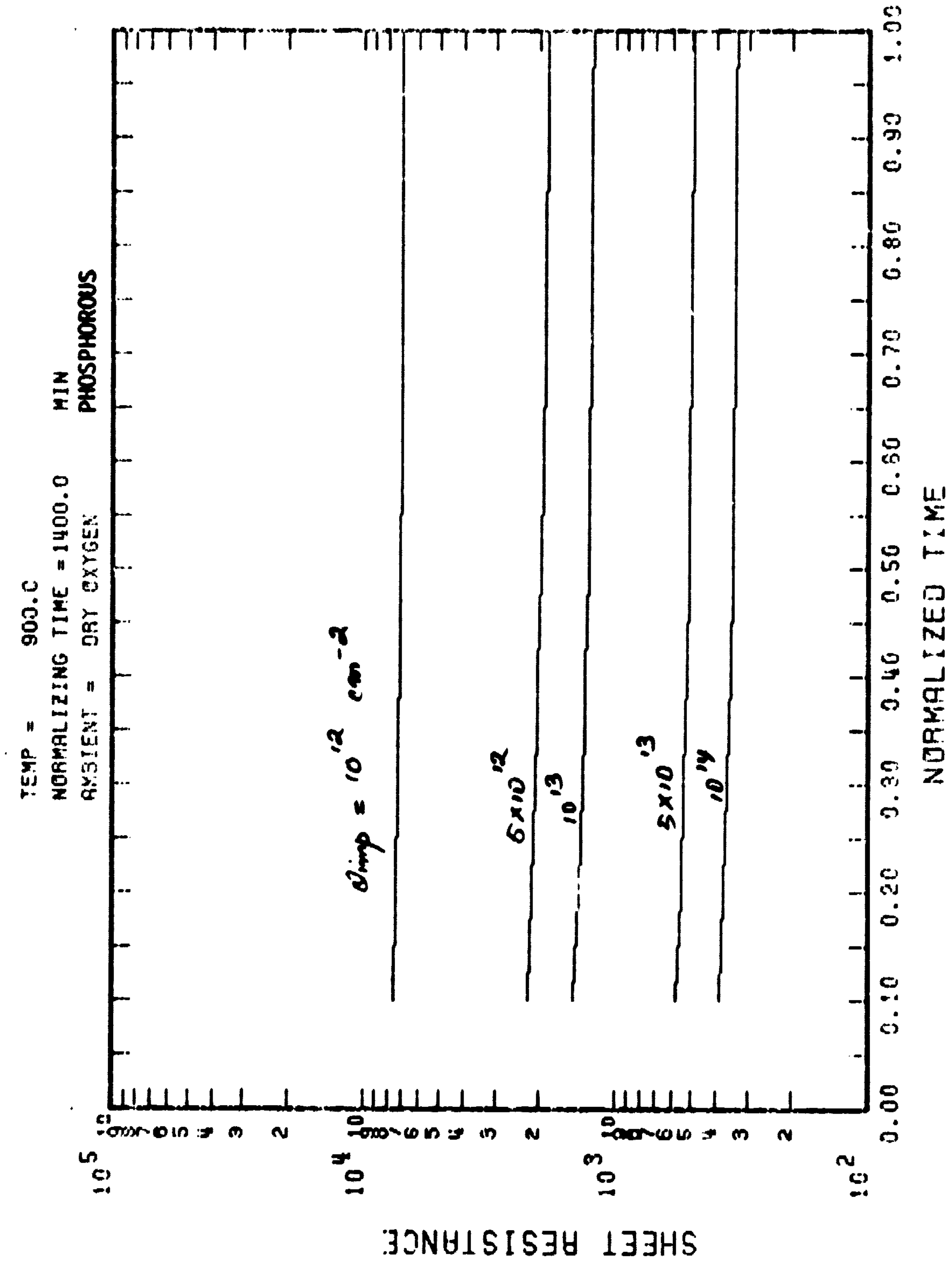
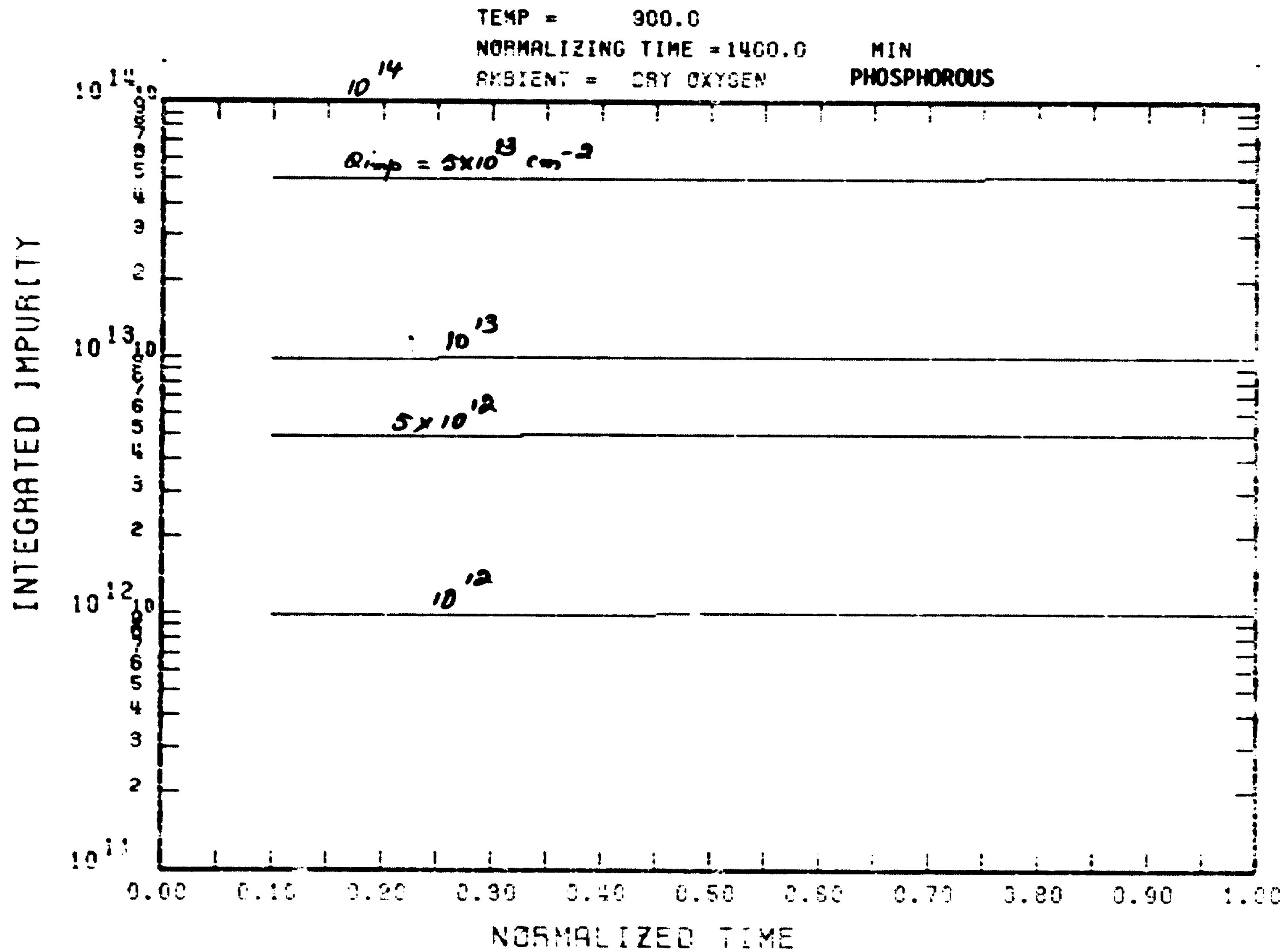
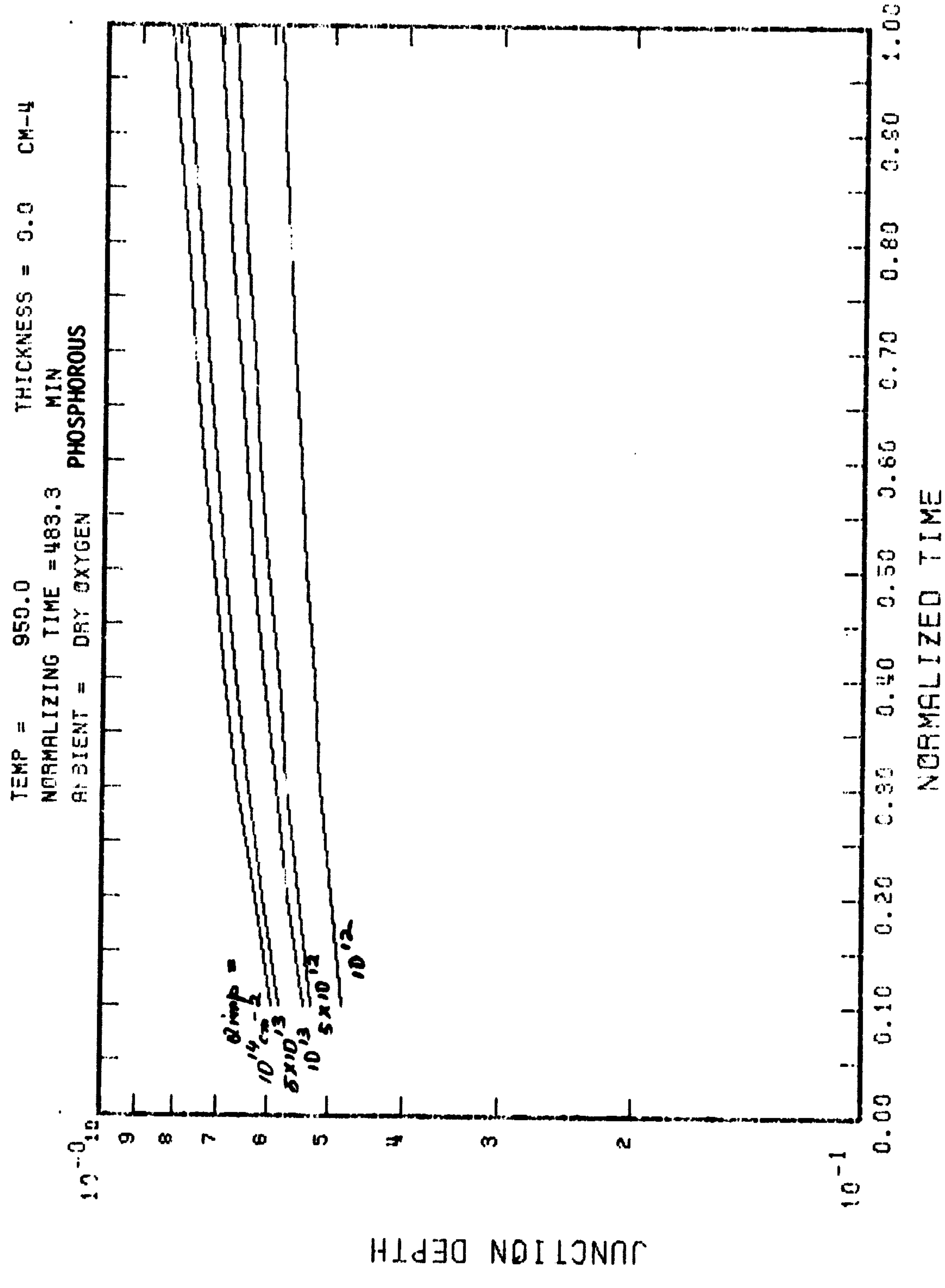




TEMP = 900.C
NORMALIZING TIME = 1400.0 MIN
AMBIENT = DRY OXYGEN
PHOSPHOROUS
Q imp = 10^12 cm^-2
6x10^12
10^13
5x10^13
10^14
SHEET RESISTANCE
NORMALIZED TIME


TEMP = 900.0
NORMALIZING TIME = 1400.0 MIN
AMBIENT = DRY OXYGEN
PHOSPHOROUS
INTEGRATED IMPURITY
NORMALIZED TIME
Qimp = 5x10^13 cm^-2
10^14
10^13
5x10^12
10^12
10^11
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


TEMP = 950.0
NORMALIZING TIME = 483.3 MIN
AMBIENT = DRY OXYGEN
THICKNESS = 0.0 CM-4
PHOSPHOROUS
NORMALIZED TIME
JUNCTION DEPTH

ORIGINAL PAGE IS
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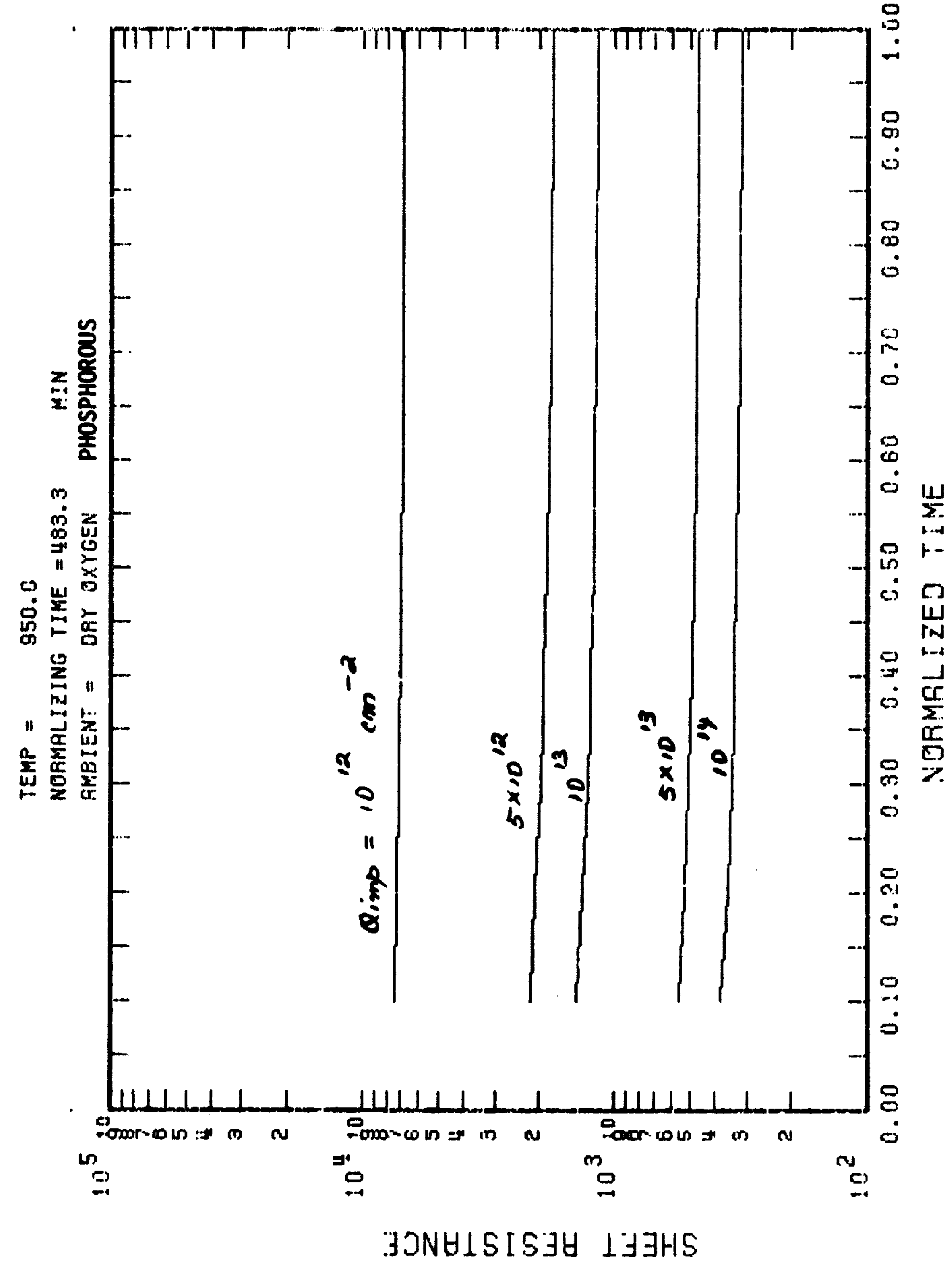
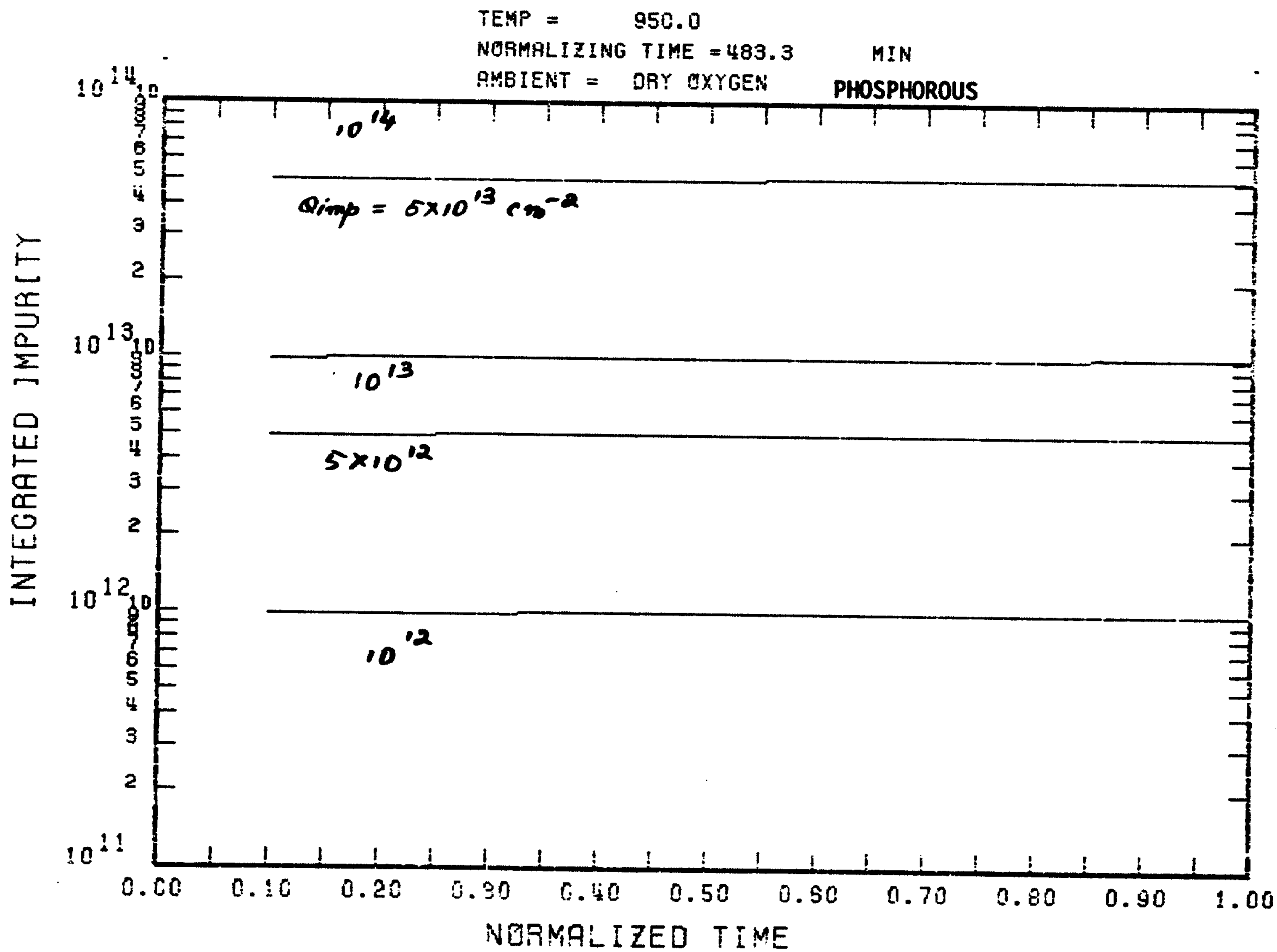
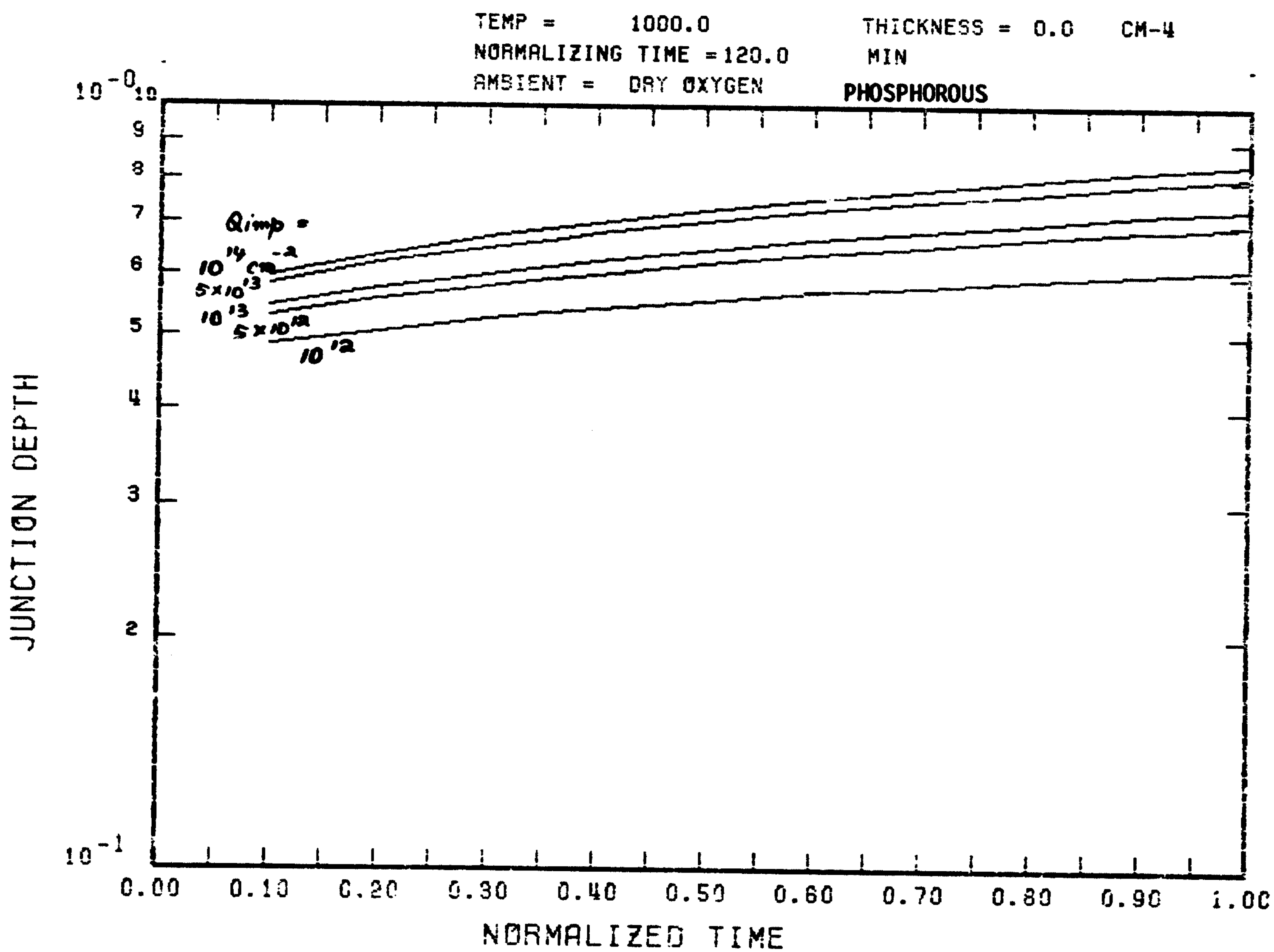
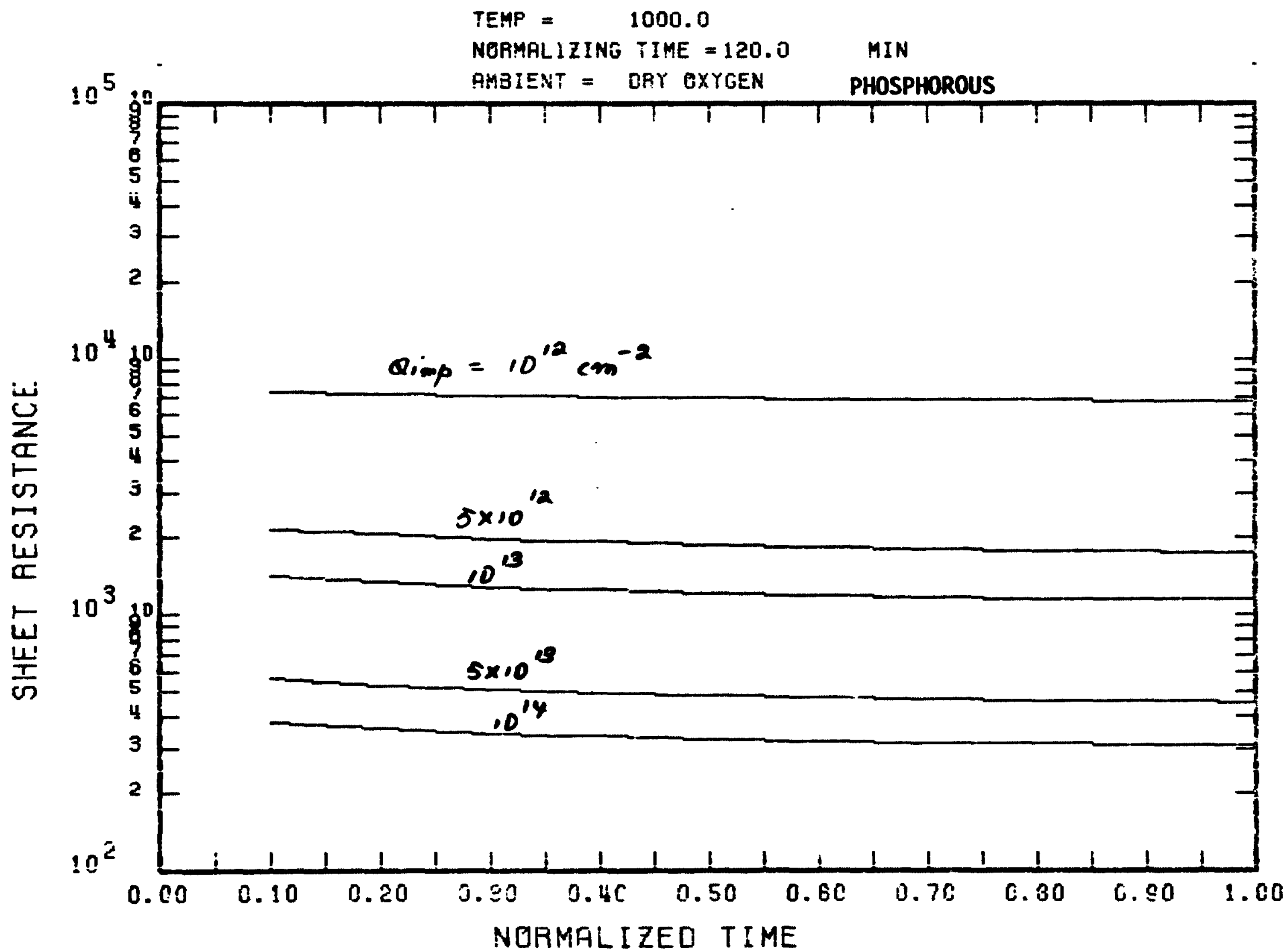
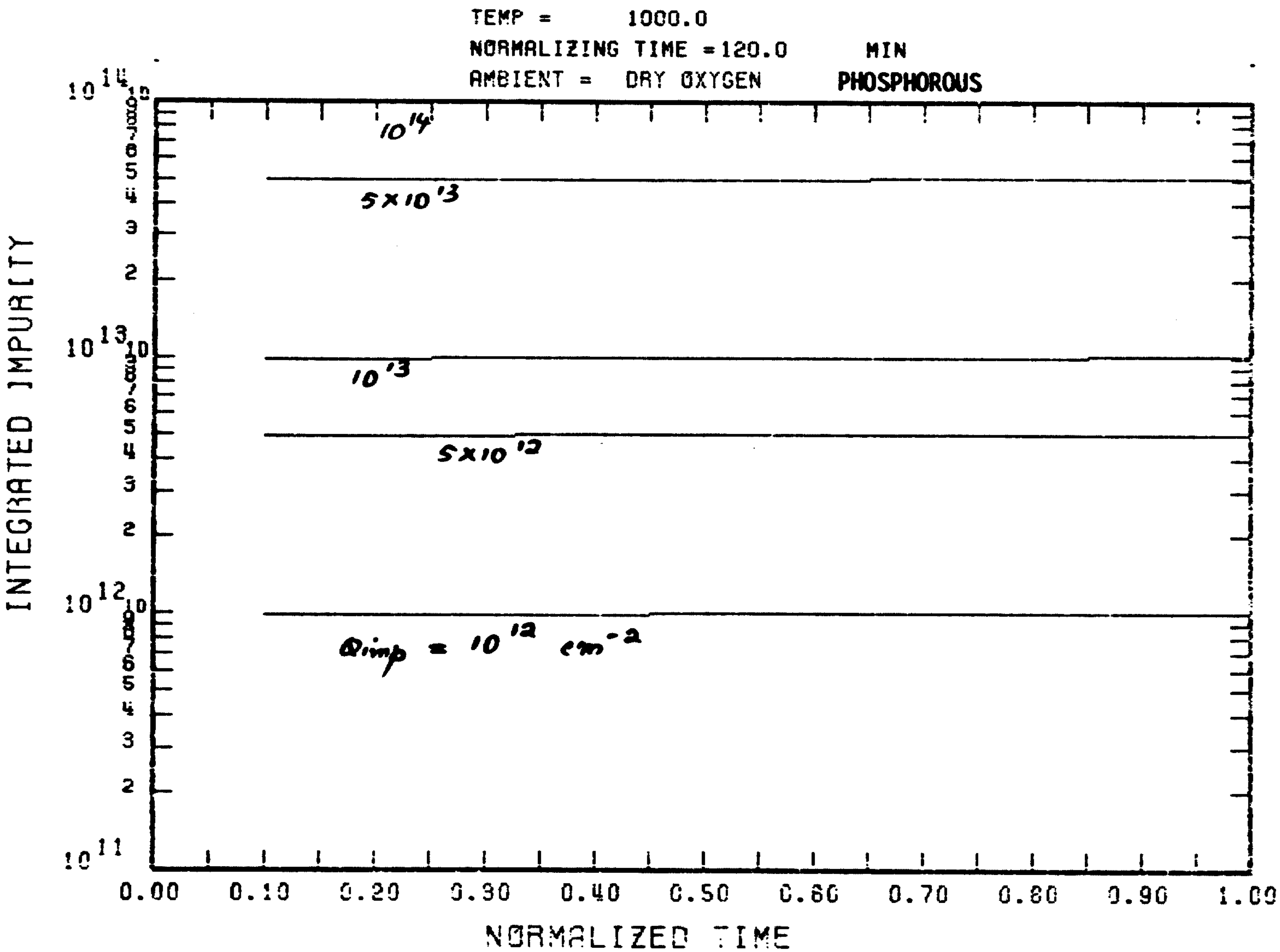


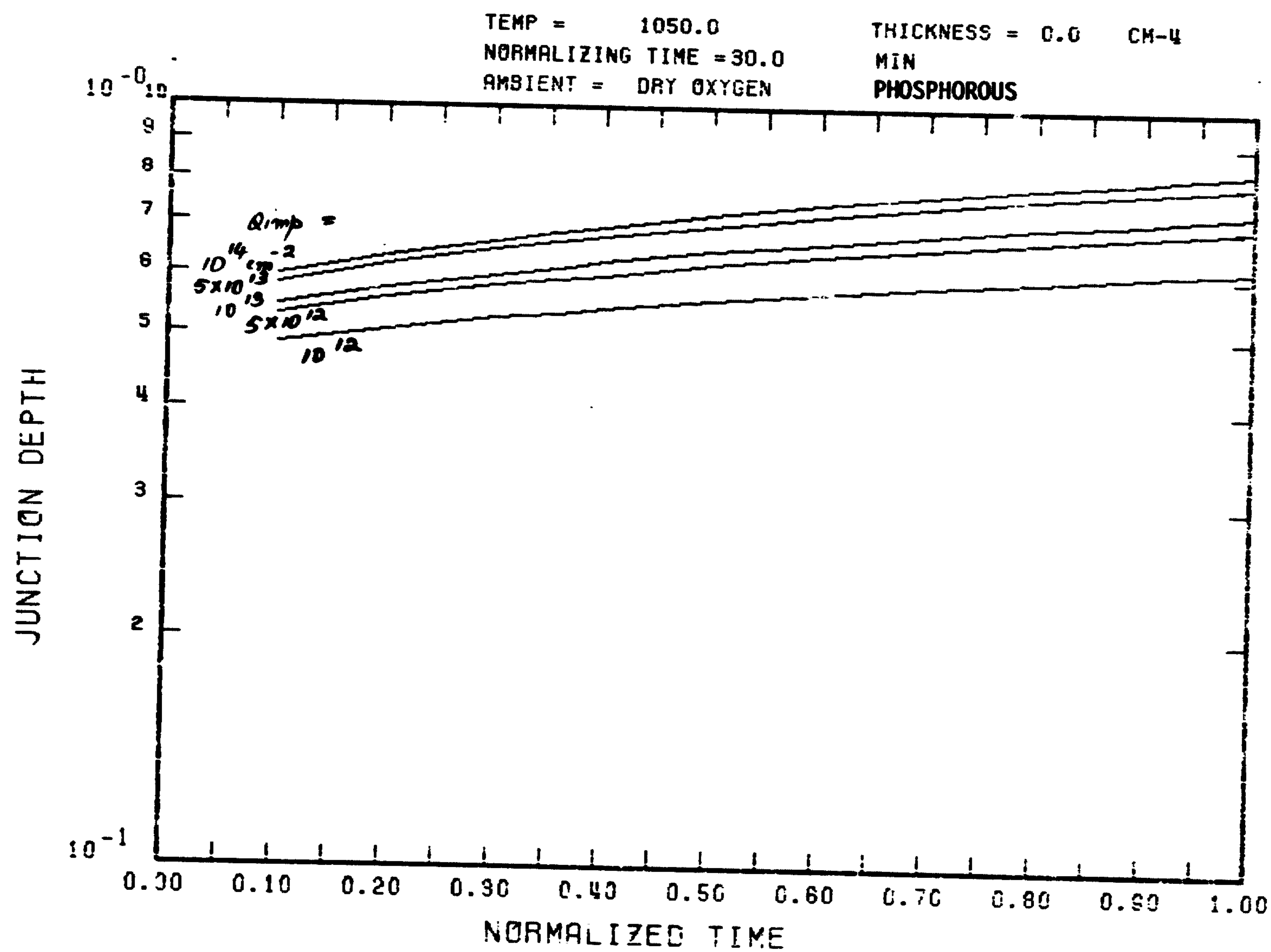

TEMP = 950.0
NORMALIZING TIME = 483.3 MIN
AMBIENT = DRY OXYGEN
PHOSPHOROUS
10^{14}
Qimp = 5×10^{13} cm^{-2}
10^{13}
5×10^{12}
10^{12}
INTEGRATED IMPURITY
10^{11}
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
NORMALIZED TIME

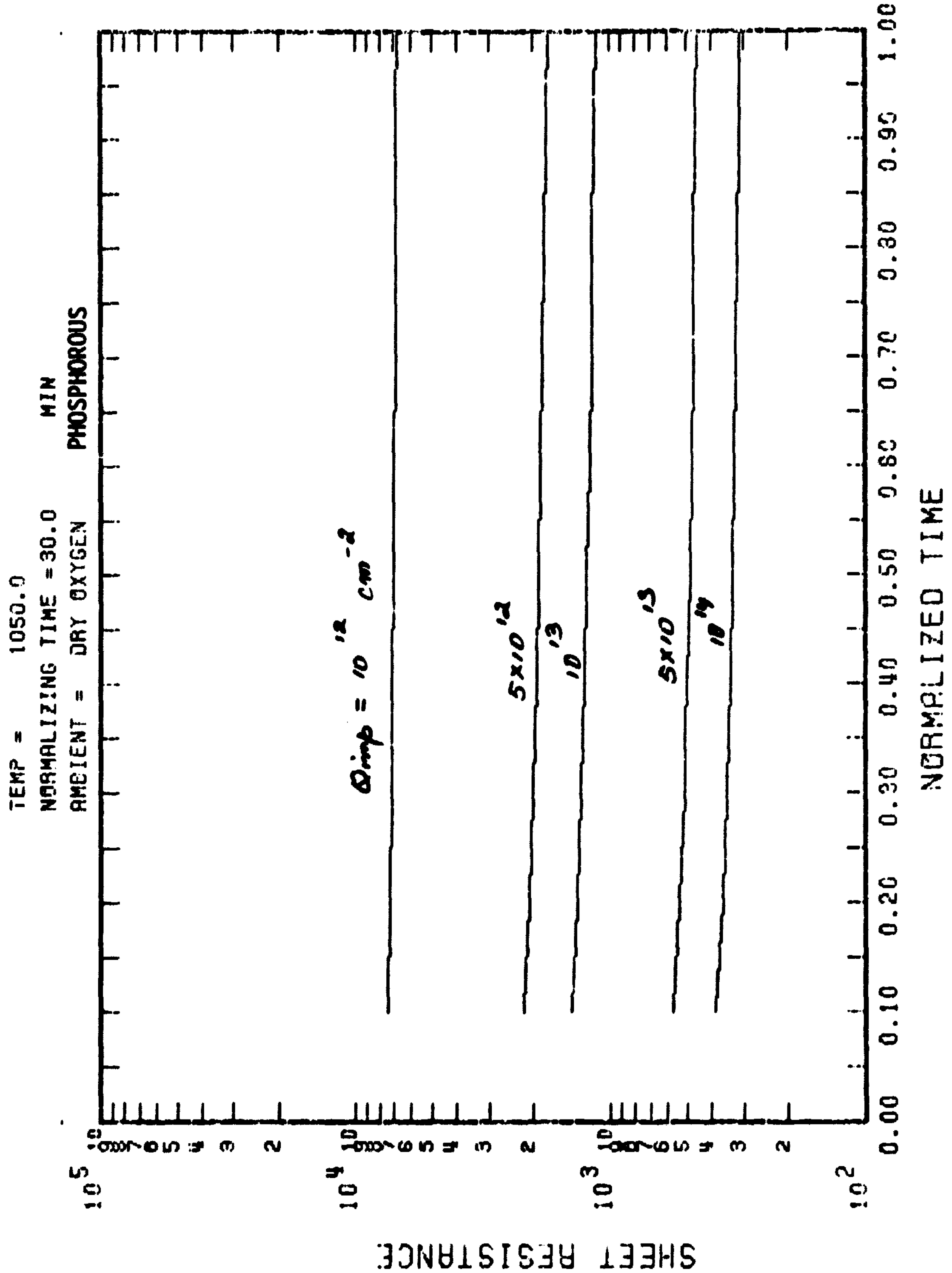


TEMP = 1000.0
NORMALIZING TIME = 120.0
AMBIENT = DRY OXYGEN
THICKNESS = 0.0 CM-4
MIN
PHOSPHOROUS
Qimp =
10^14 cm^-2
5x10^13
10^13
5x10^12
10^12
JUNCTION DEPTH
NORMALIZED TIME
10^-0
10^-1
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


TEMP = 1000.0
NORMALIZING TIME = 120.0 MIN
AMBIENT = DRY OXYGEN
PHOSPHOROUS
Qimp = 10^12 cm^-2
5x10^12
10^13
5x10^13
10^14
SHEET RESISTANCE
NORMALIZED TIME
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
10^2
10^3
10^4
10^5


TEMP = 1000.0
NORMALIZING TIME = 120.0 MIN
AMBIENT = DRY OXYGEN
PHOSPHOROUS
10^{14}
5×10^{13}
10^{13}
5×10^{12}
$Q_{imp} = 10^{12}\ cm^{-2}$
INTEGRATED IMPURITY
10^{14}
10^{13}
10^{12}
10^{11}
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
NORMALIZED TIME


TEMP = 1050.0
NORMALIZING TIME = 30.0 MIN
AMBIENT = DRY OXYGEN
THICKNESS = 0.0 CM-4
PHOSPHOROUS
Qimp =
10^14 cm^-2
5x10^13
10^13
5x10^12
10^12
JUNCTION DEPTH
NORMALIZED TIME
10^-0
10^-1
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


TEMP = 1050.0
NORMALIZING TIME = 30.0 MIN
AMBIENT = DRY OXYGEN
PHOSPHOROUS
Qimp = 10^12 cm^-2
5x10^12
10^13
5x10^13
10^14
NORMALIZED TIME
SHEET RESISTANCE

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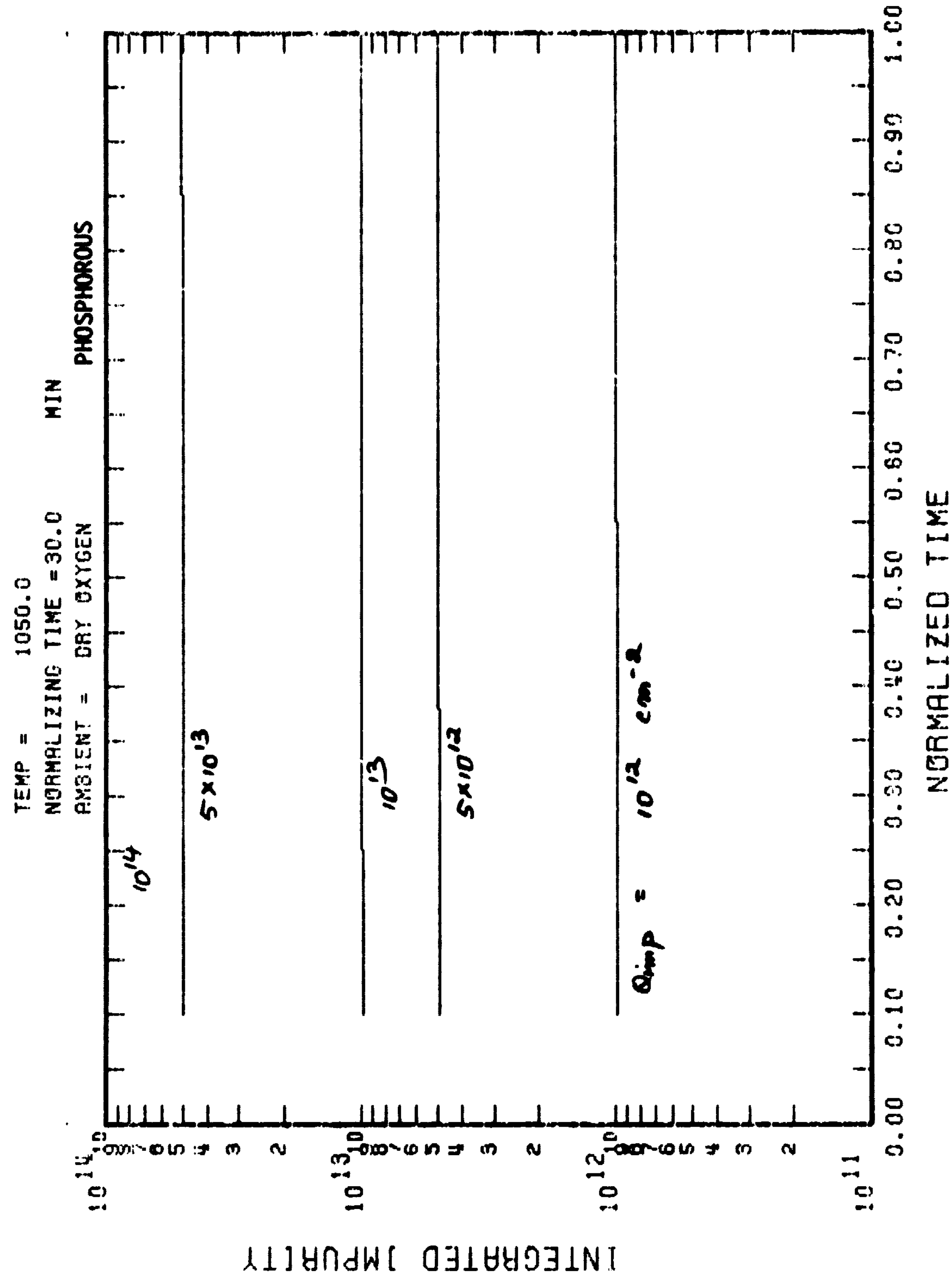
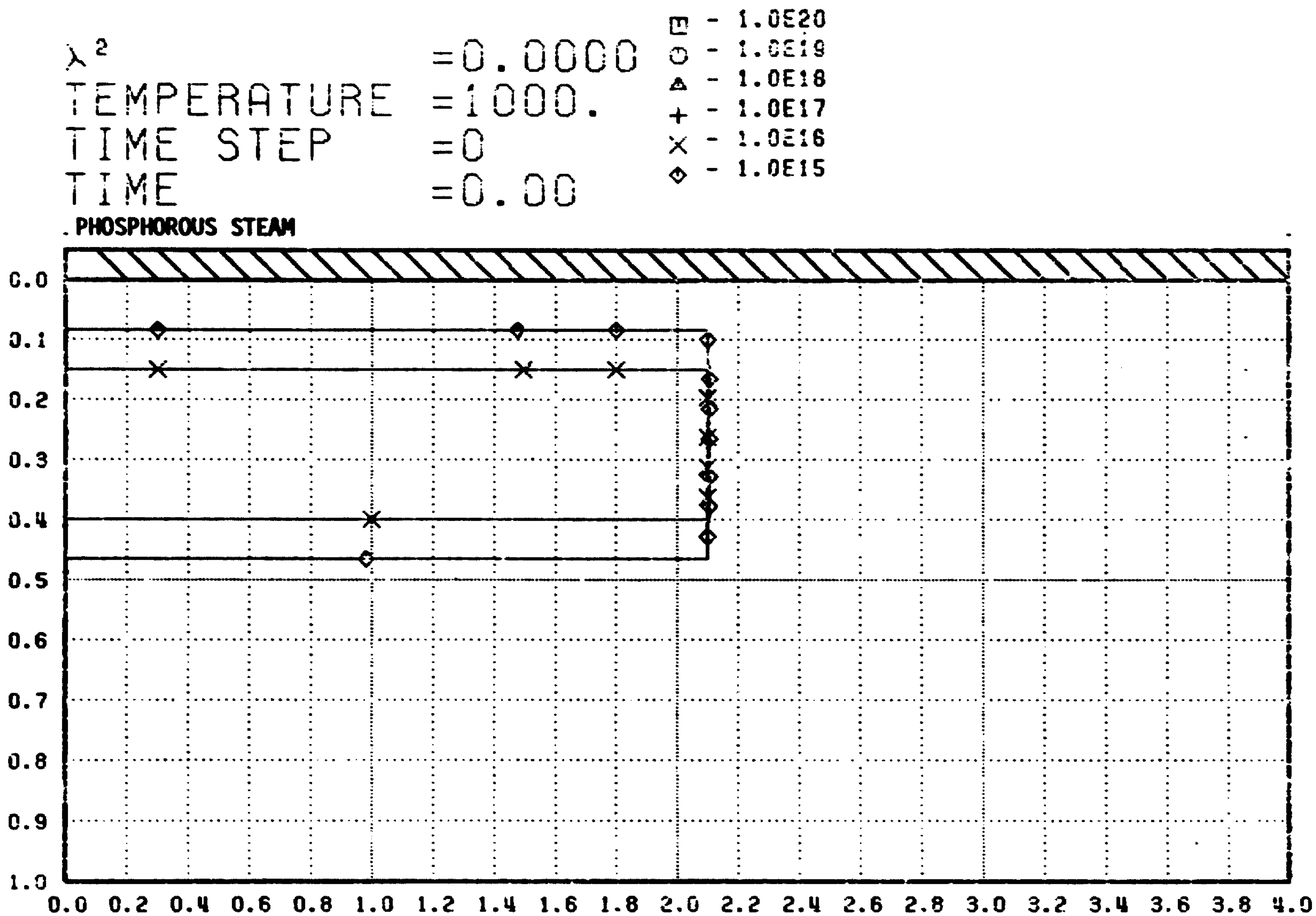
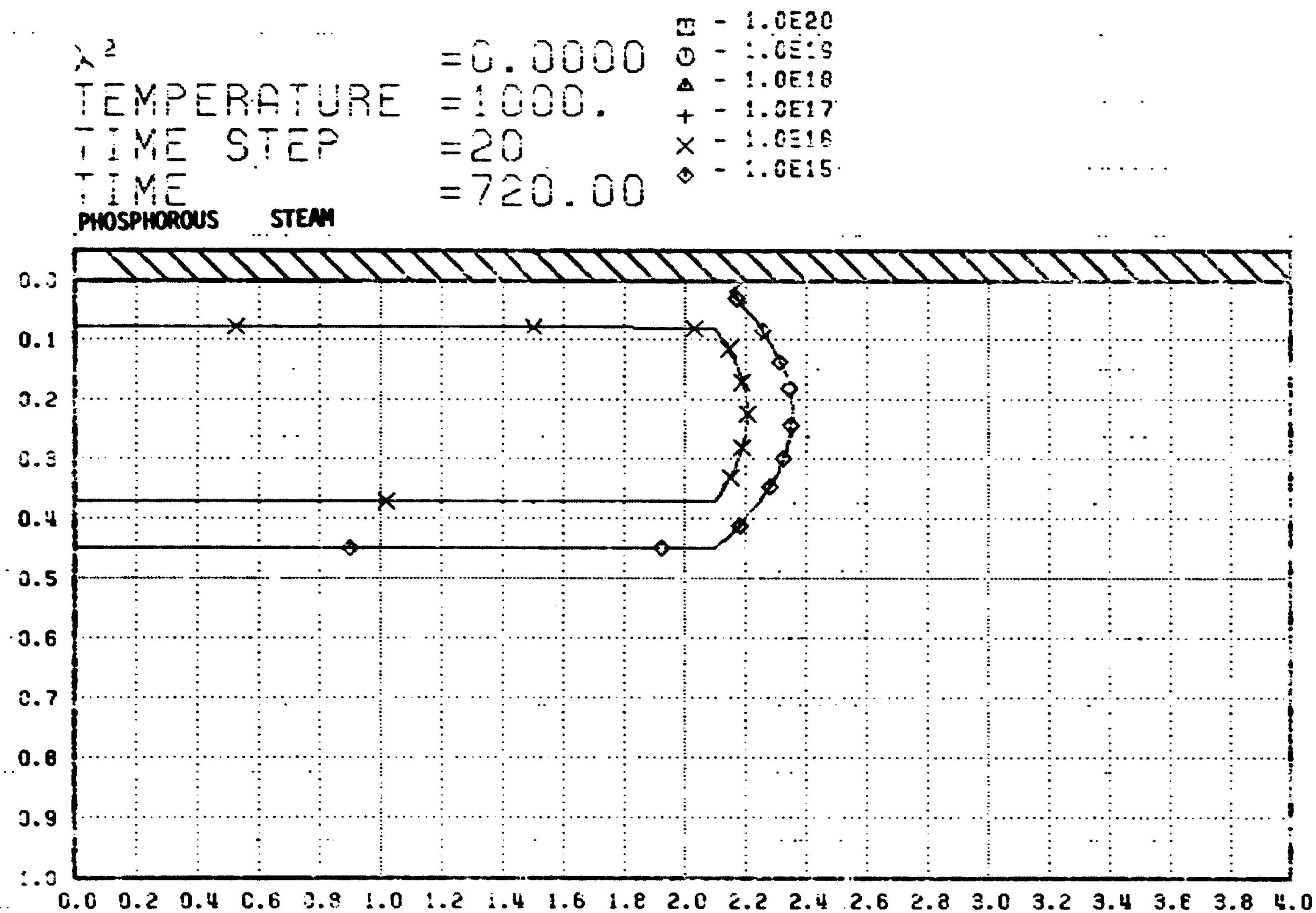



λ 2 =0.0000
TEMPERATURE =1000.
TIME STEP =0
TIME =0.00
□ - 1.0E20
○ - 1.0E19
△ - 1.0E18
+ - 1.0E17
× - 1.0E16
◇ - 1.0E15
PHOSPHOROUS STEAM
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0



X^2 =0.0000
TEMPERATURE =1000.
TIME STEP =20
TIME =720.00
□ - 1.0E20
○ - 1.0E19
△ - 1.0E18
+ - 1.0E17
× - 1.0E16
◇ - 1.0E15
PHOSPHOROUS
STEAM
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0

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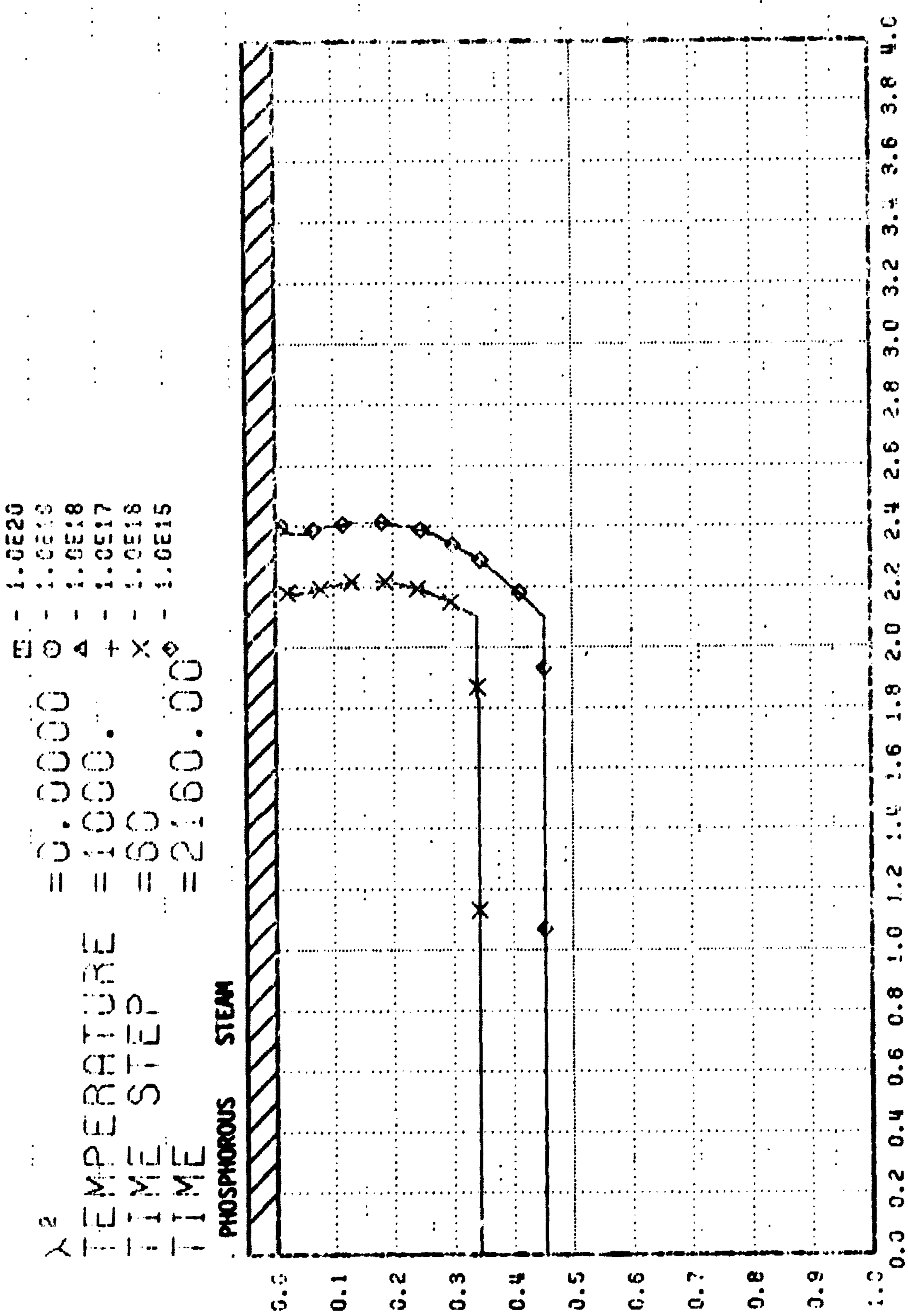

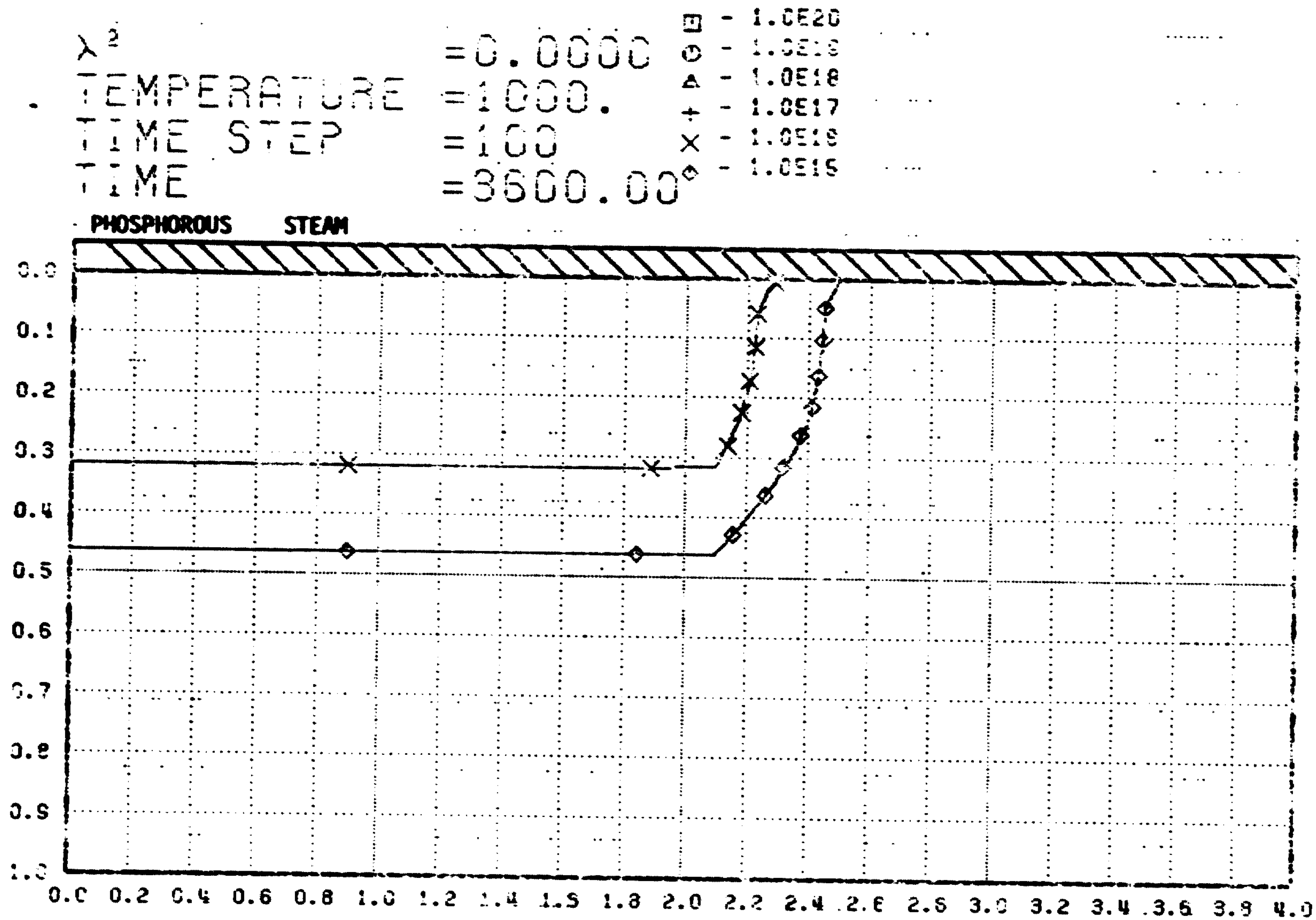

λ² =0.0000
TEMPERATURE =1000.
TIME STEP =100
TIME =3600.00
□ - 1.0E20
⊖ - 1.0E19
△ - 1.0E18
+ - 1.0E17
× - 1.0E16
◇ - 1.0E15
PHOSPHOROUS
STEAM
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
4.0

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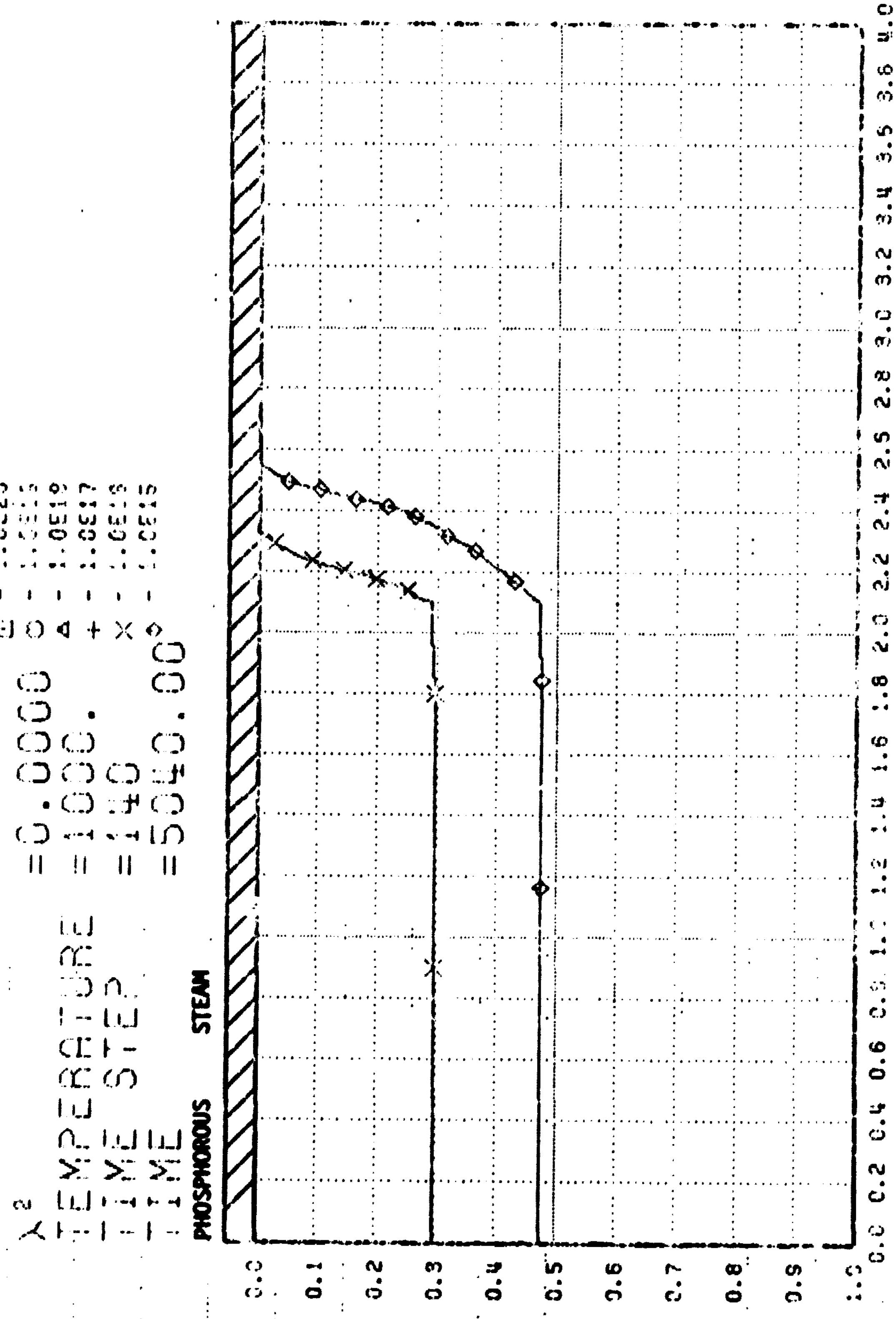
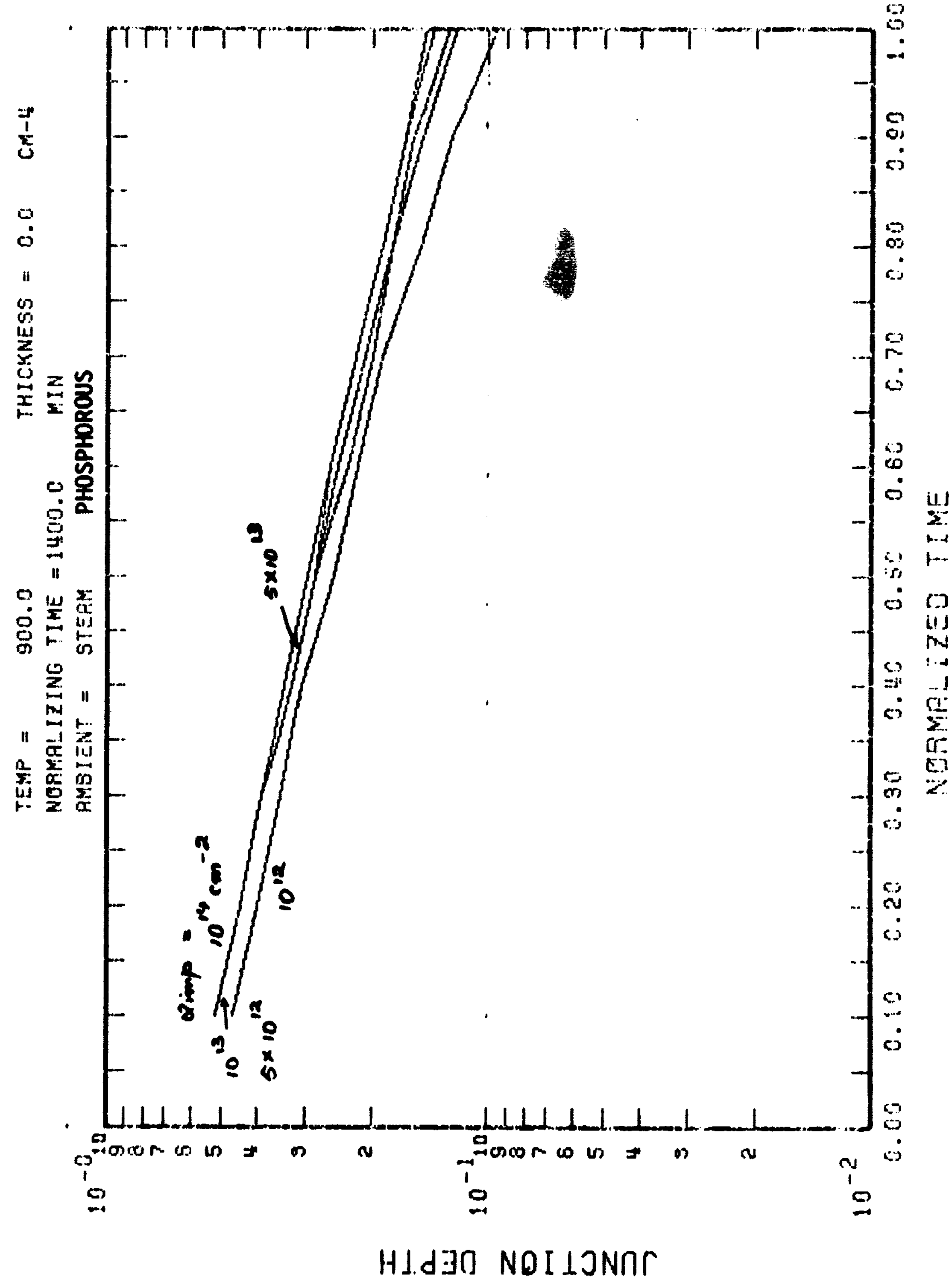
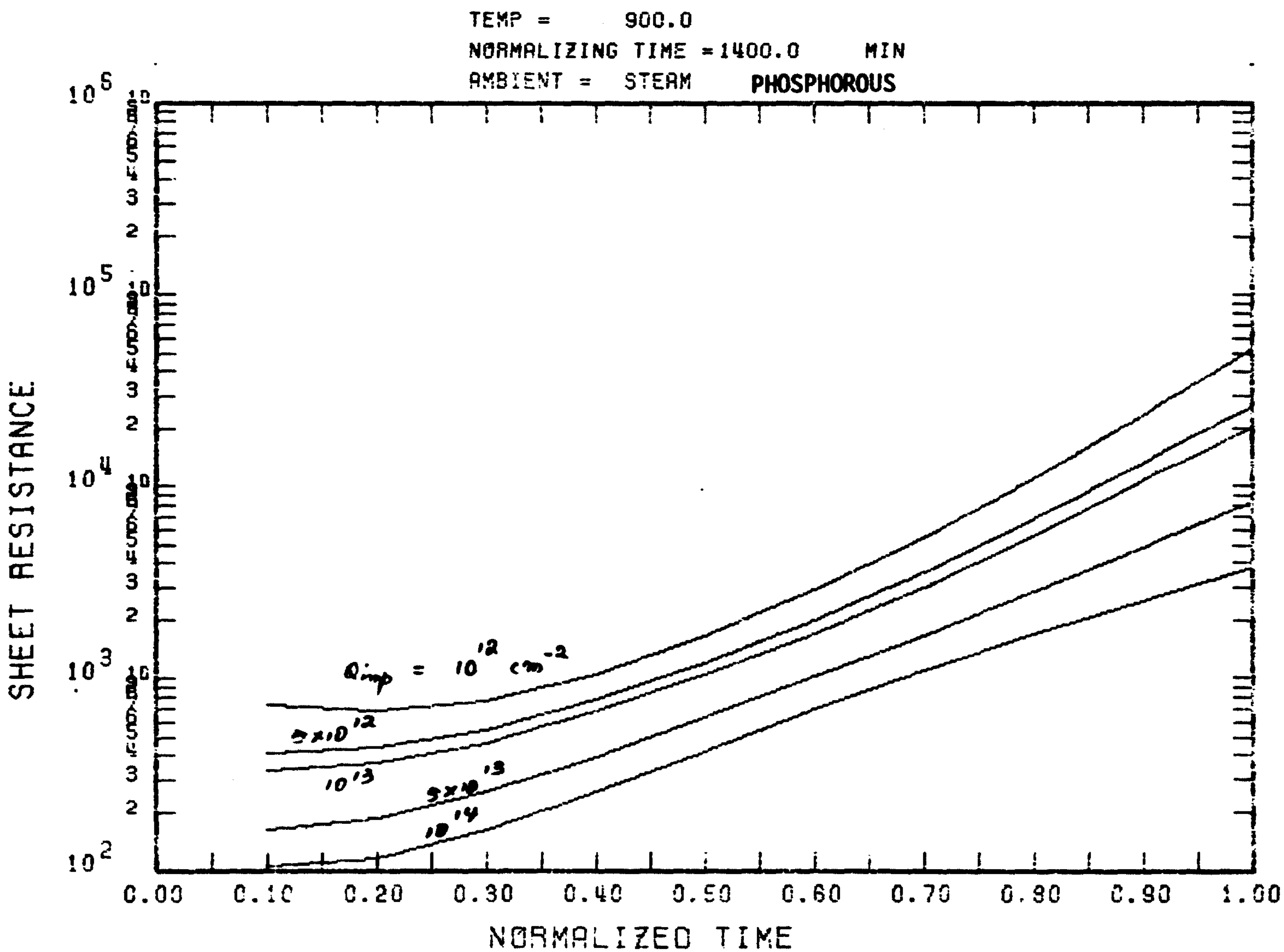
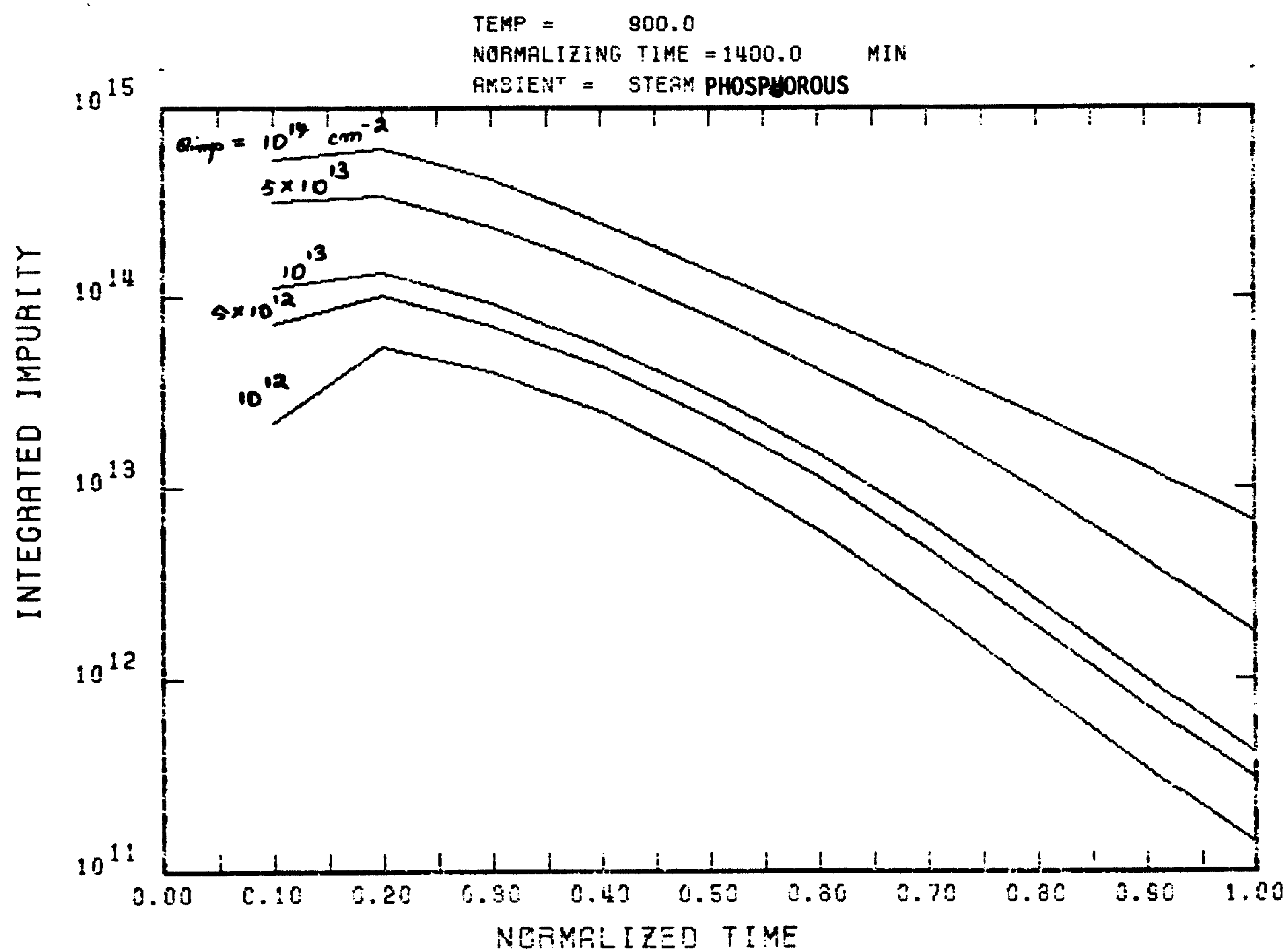



TEMP = 900.0 THICKNESS = 0.0 CM-4
NORMALIZING TIME = 1400.0 MIN
AMBIENT = STEAM
PHOSPHOROUS
Qimp = 10^14 cm^-2
10^13
5x10^12
10^12
5x10^13
JUNCTION DEPTH
NORMALIZED TIME


TEMP = 900.0
NORMALIZING TIME = 1400.0 MIN
AMBIENT = STEAM PHOSPHOROUS
SHEET RESISTANCE
NORMALIZED TIME
$Q_{imp} = 10^{12}\ cm^{-2}$
5×10^{12}
10^{13}
5×10^{13}
10^{14}
10^2
10^3
10^4
10^5
10^6
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


TEMP = 900.0
NORMALIZING TIME = 1400.0 MIN
AMBIENT = STEAM PHOSPHOROUS
INTEGRATED IMPURITY
NORMALIZED TIME
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
10^15
10^14
10^13
10^12
10^11
Q_imp = 10^14 cm^-2
5×10^13
10^13
5×10^12
10^12

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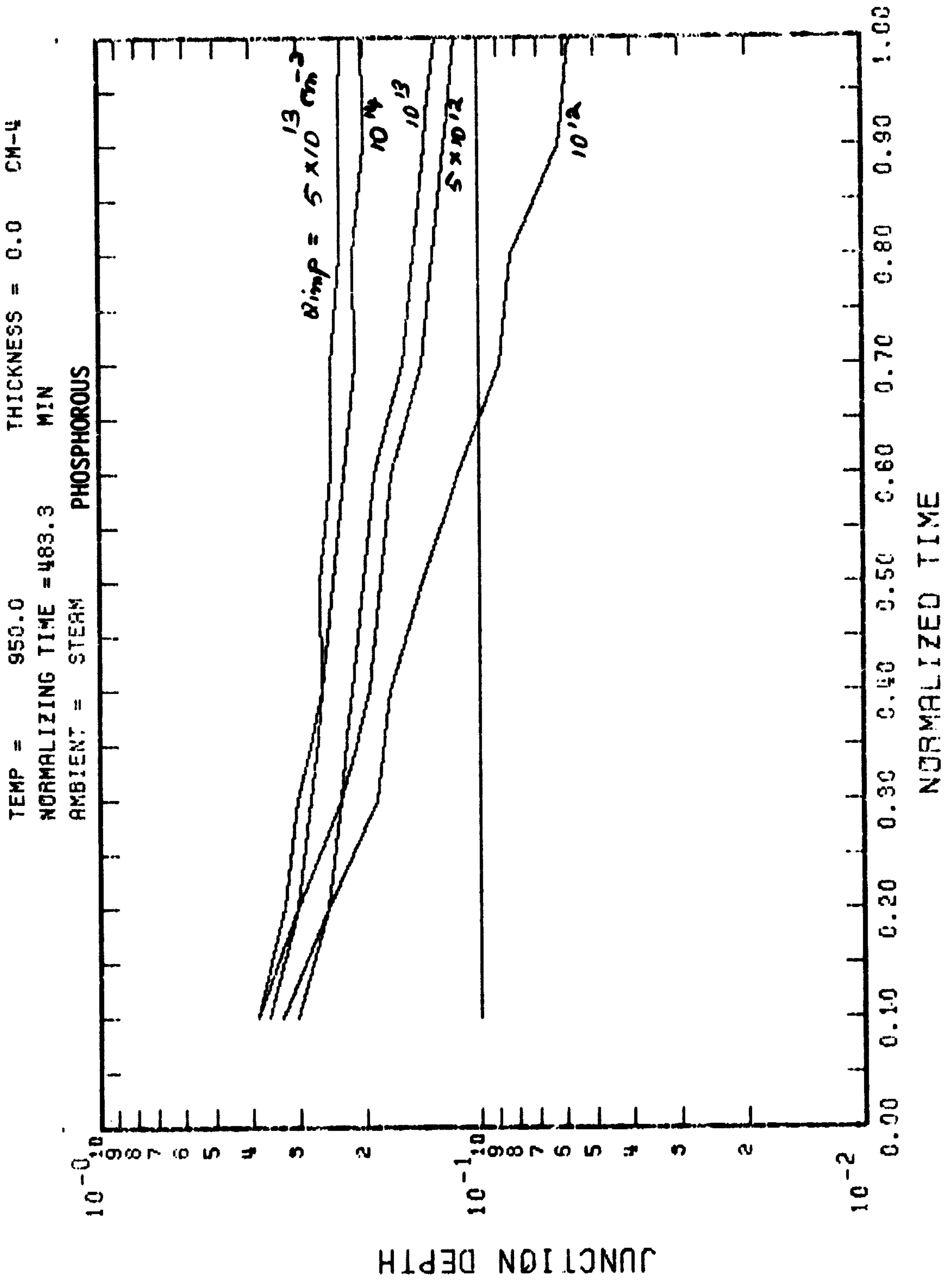
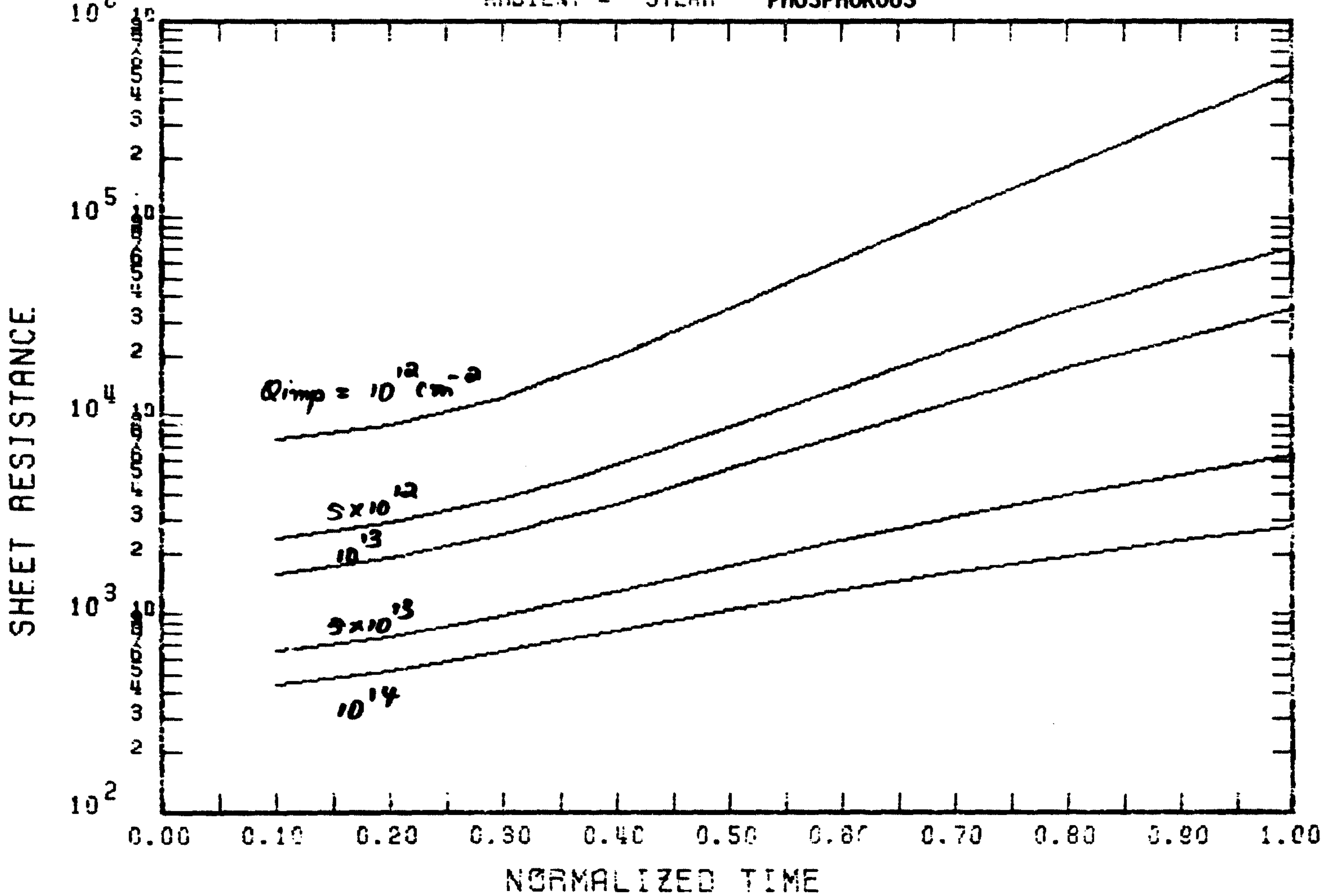
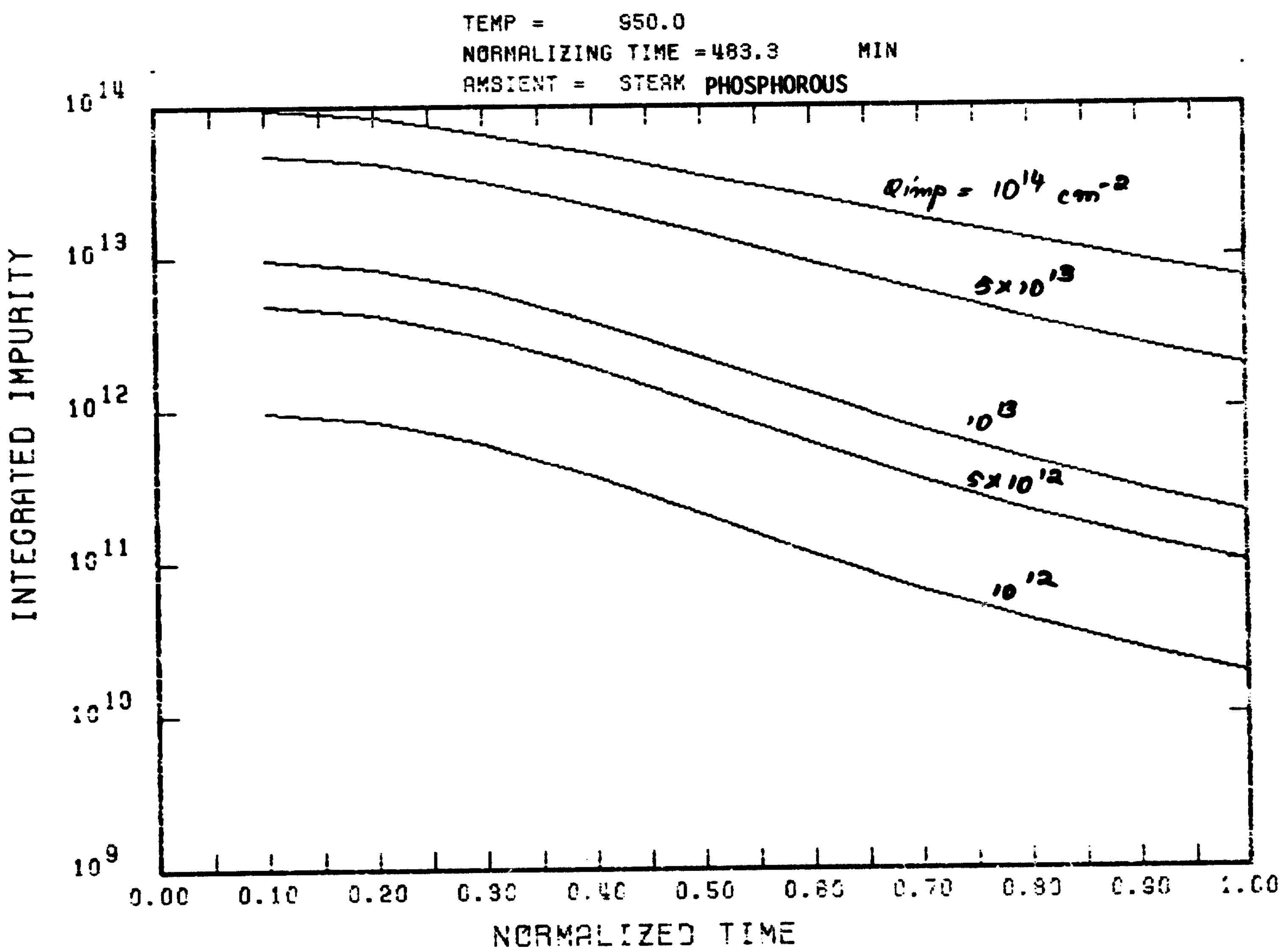


TEMP = 950.0
NORMALIZING TIME = 483.3 MIN
AMBIENT = STEAM PHOSPHOROUS




TEMP = 950.0
NORMALIZING TIME = 483.3 MIN
AMBIENT = STEAM PHOSPHOROUS
INTEGRATED IMPURITY
NORMALIZED TIME
Qimp = 10^14 cm^-2
5x10^13
10^13
5x10^12
10^12
10^14
10^13
10^12
10^11
10^10
10^9
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

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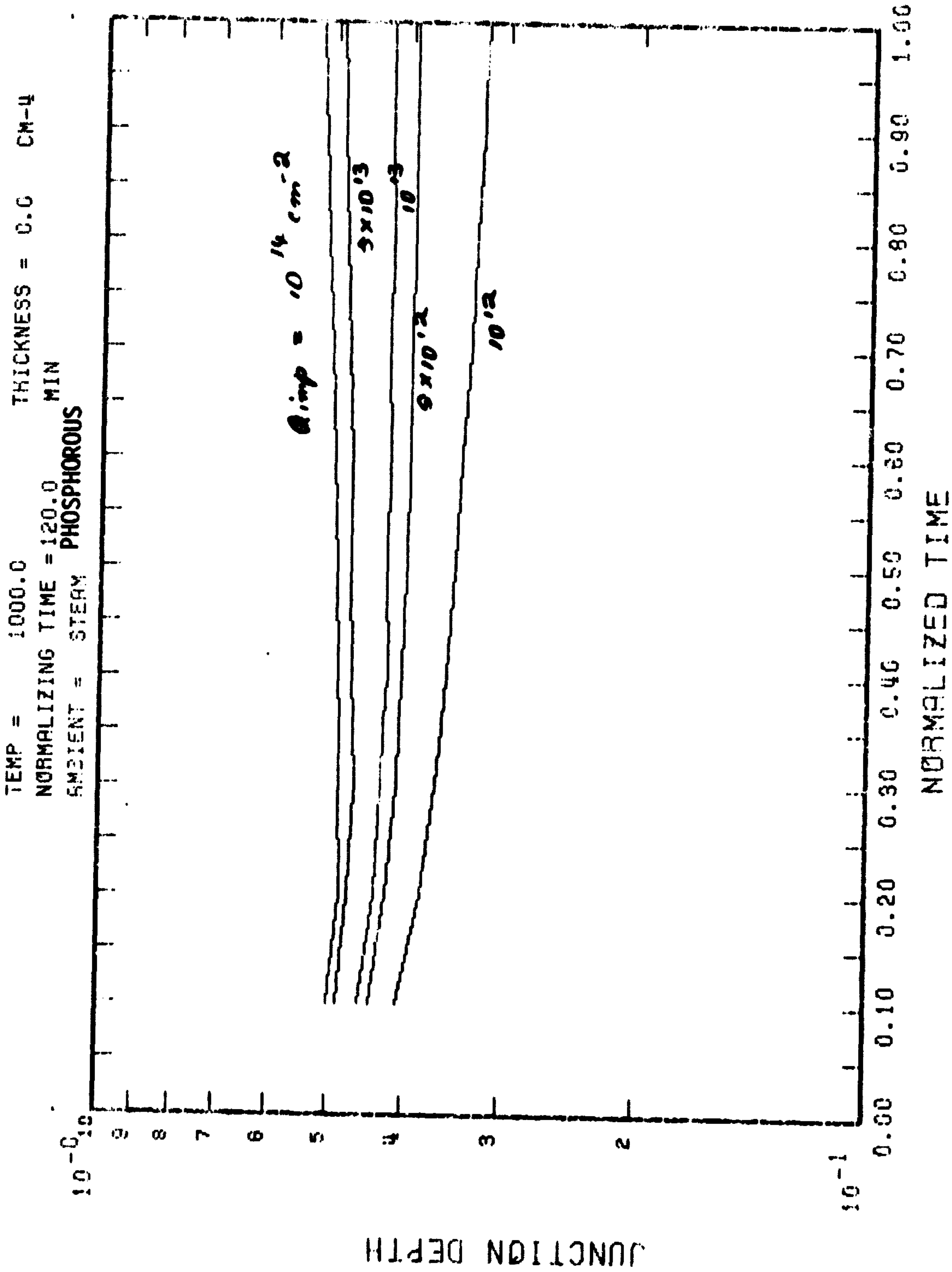
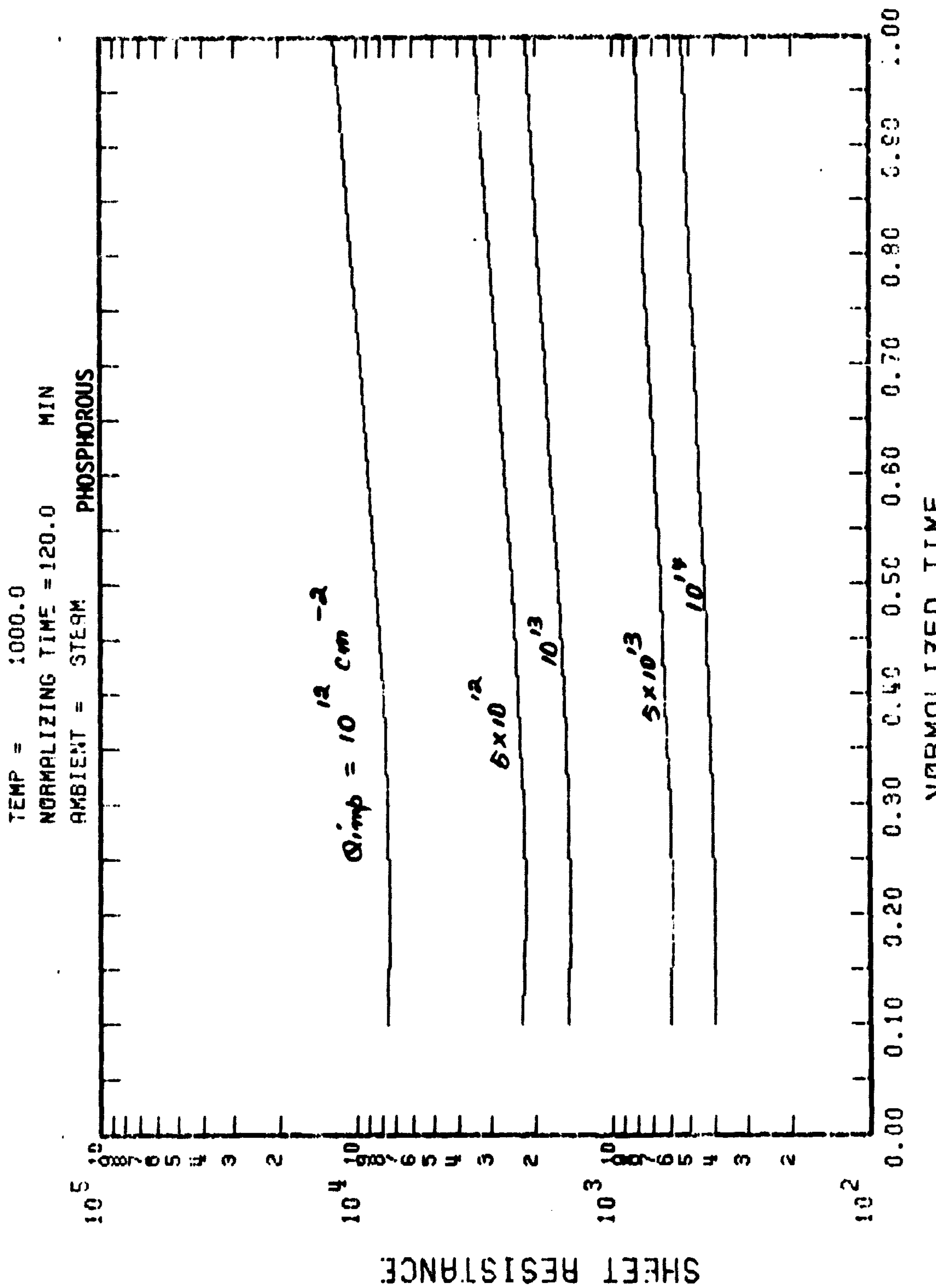
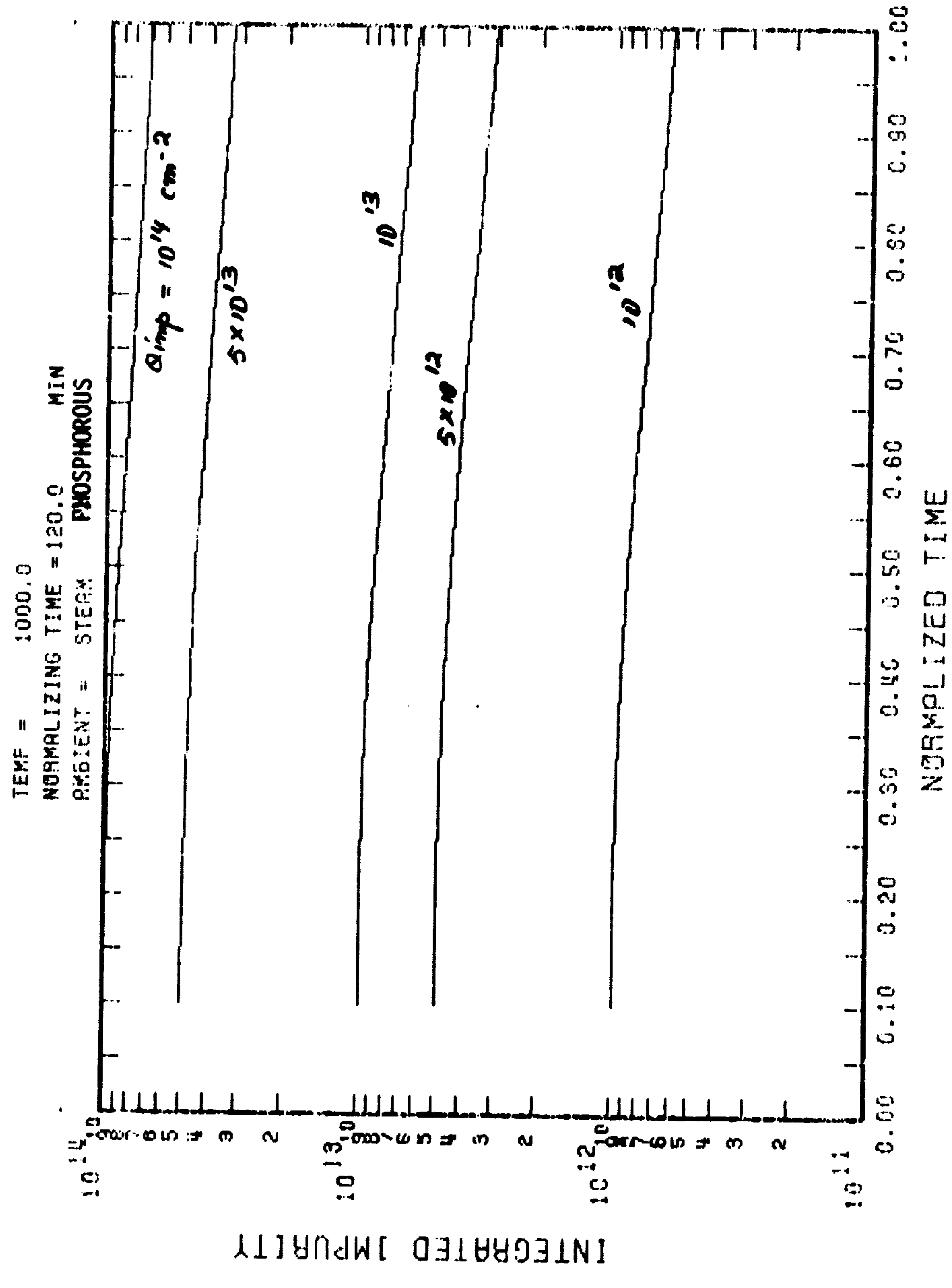
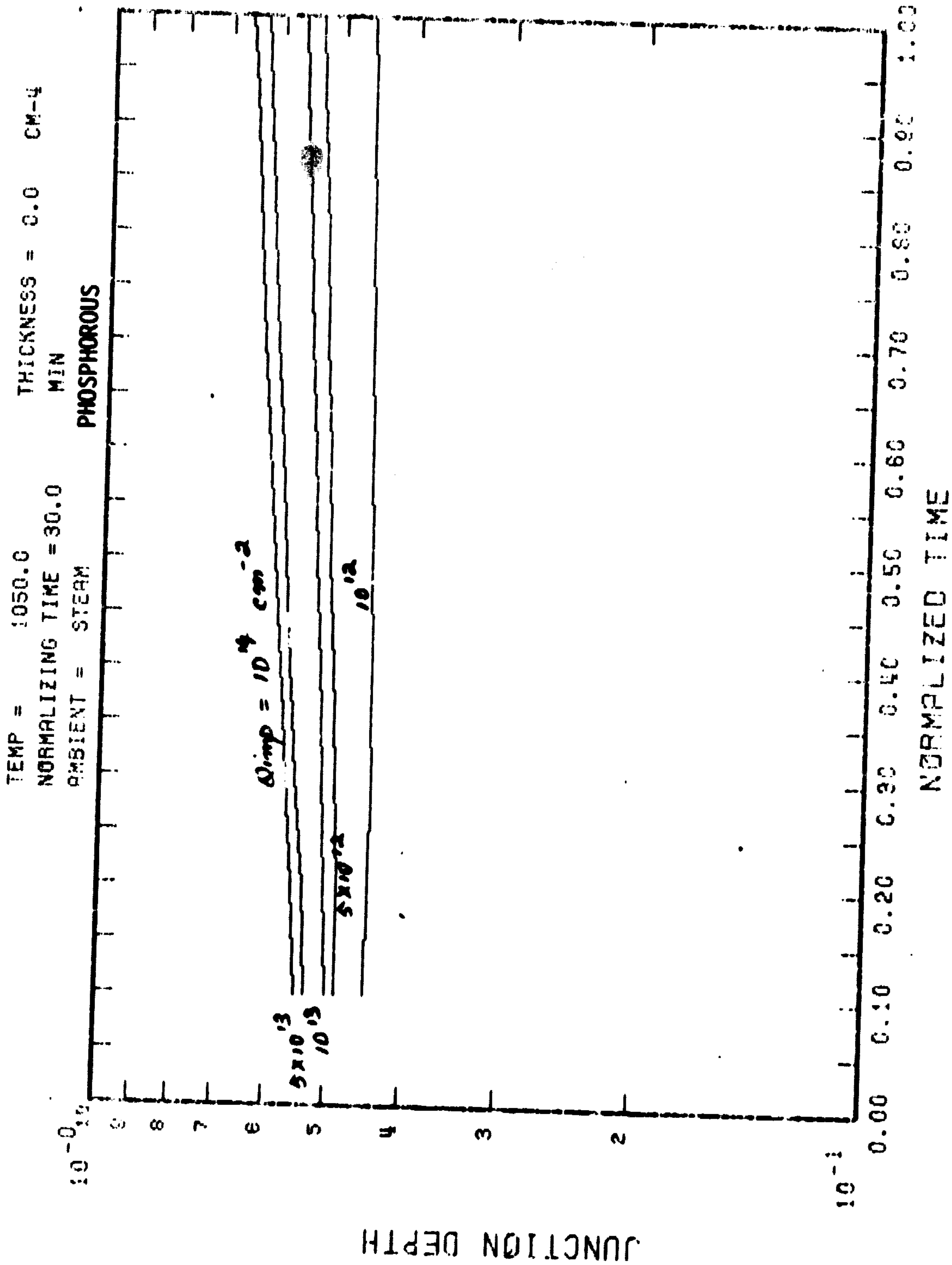



TEMP = 1000.0
NORMALIZING TIME = 120.0 MIN
AMBIENT = STEAM
PHOSPHOROUS
$Q'_{imp} = 10^{12}$ cm^{-2}
6×10^{12}
10^{13}
5×10^{13}
10^{14}
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
NORMALIZED TIME
10^2
10^3
10^4
10^5
SHEET RESISTANCE


TEMP = 1000.0
NORMALIZING TIME = 120.0 MIN
AMBIENT = STEAM
PHOSPHOROUS
Qimp = 10^14 cm^-2
5×10^13
10^13
5×10^12
10^12
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
NORMALIZED TIME
10^11 10^12 10^13 10^14
INTEGRATED IMPURITY



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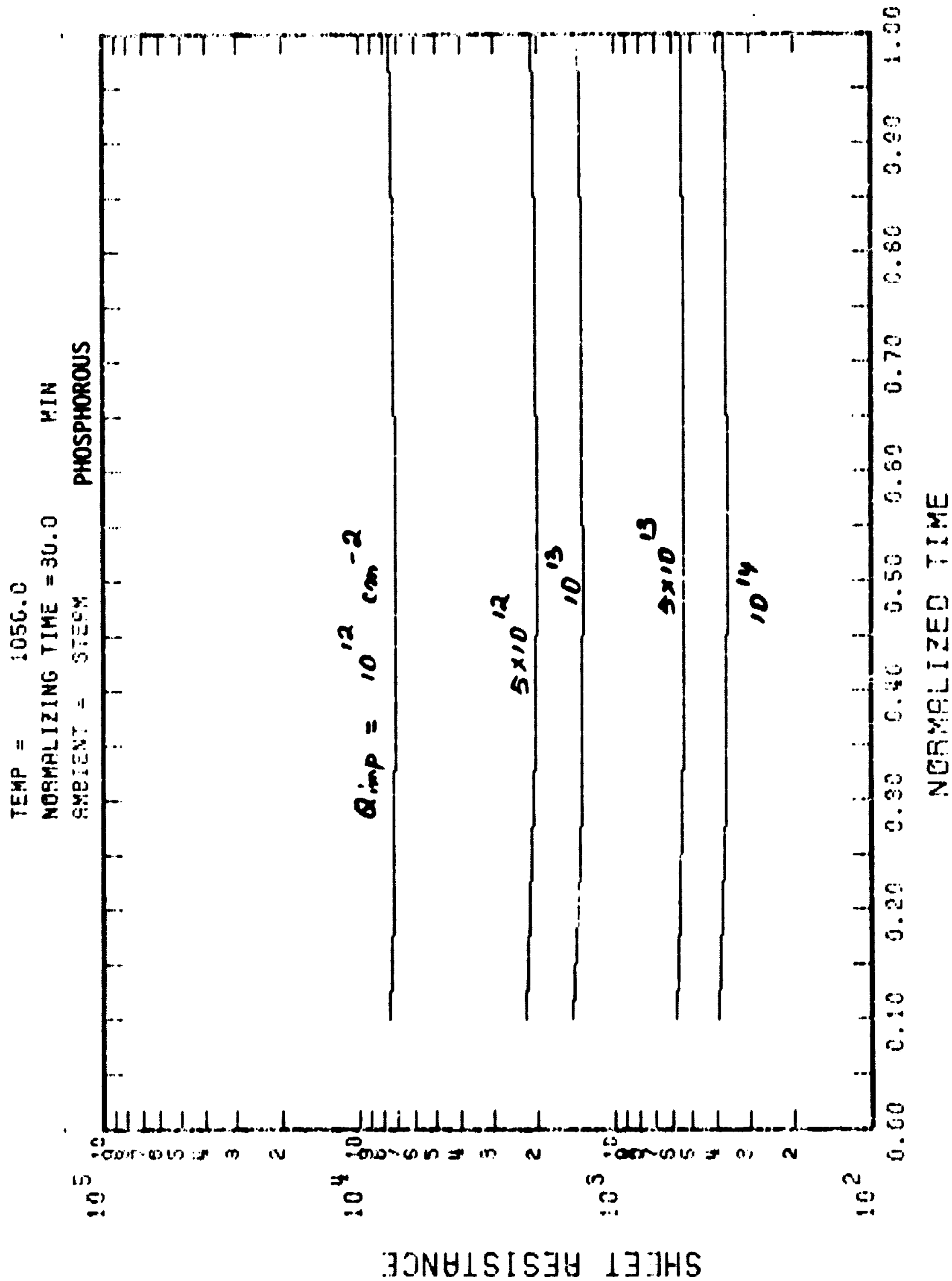

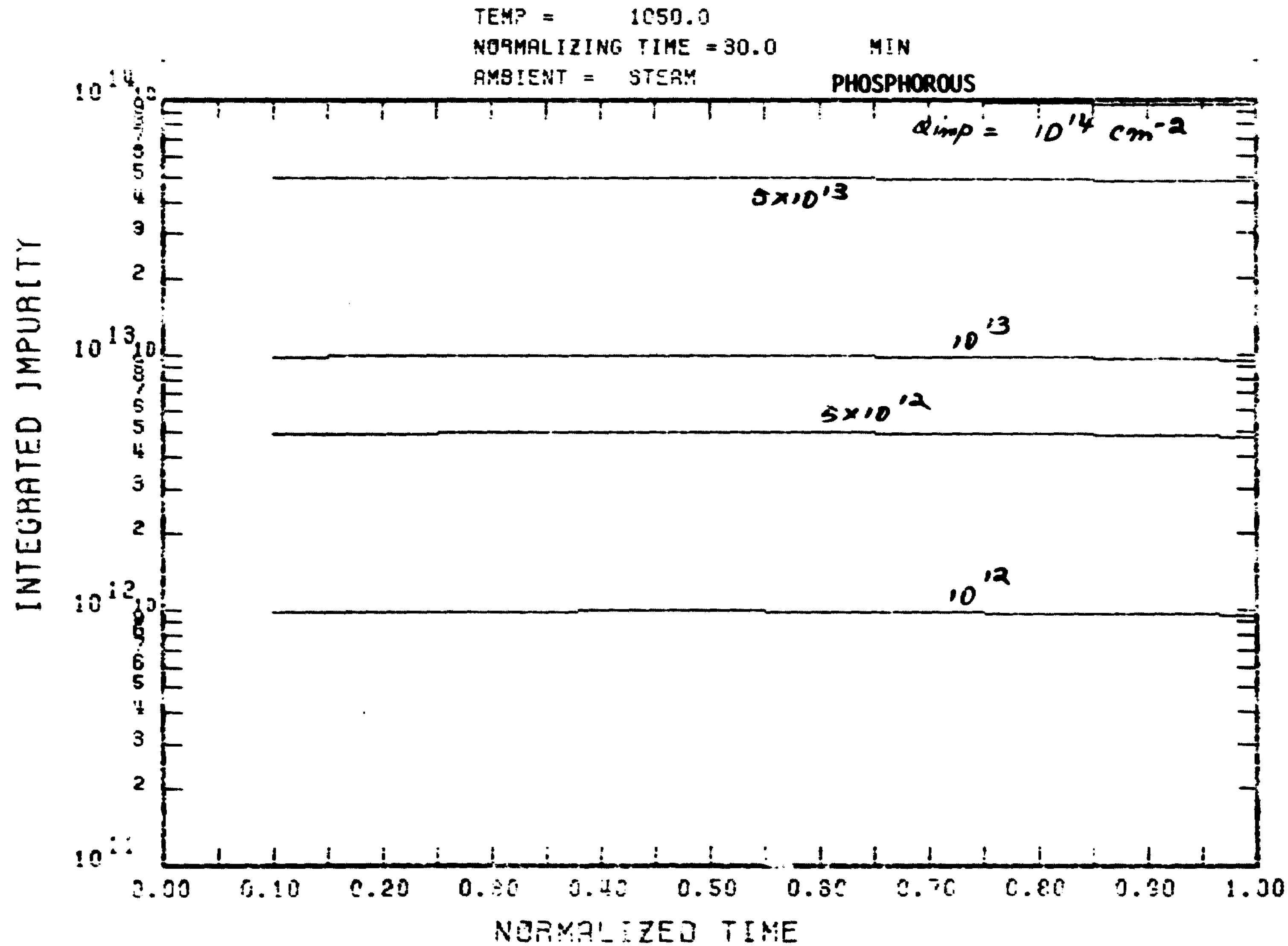
TEMP = 1050.0
NORMALIZING TIME = 30.0 MIN
AMBIENT = STEAM
PHOSPHOROUS
Q_{imp} = 10^{14} cm^{-2}
5×10^{13}
10^{13}
5×10^{12}
10^{12}
INTEGRATED IMPURITY
NORMALIZED TIME
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

```
MICRON*SOS2(1).SMPLOT
C   ***  SHRFJN PLOT PROGRAM  ***
C
C        ***  DATA DECK  ***
C
C   ***1ST CARD
C      NPLT = # OF DATA SET(FOR DIFF. VALUES OF IMPLNT. DOSES)
C      NSTP1 TO NSTP5= # OF TIME STEPS FOR A VALUE OF NPLT(MAX. 5 VALUES)
C      FIELD 8I10
C   ***2ND CARD, 4TH AND 6TH CARD
C      IX,IY = X AND Y AXIS LABELS RESPECTIVELY
C      1ST, 2ND AND 3RD PLOTS ARE RS, XJ AND Q VS TIME PLOTS RESP.
C      JCOD = PUT 0 FOR NO GRID
C      FIELD 2(5A6),2I10
C   ***3RD CARD
C      JGRID = # OF DIV. IN Y AXIS
C      IGRID = # OF DIV. IN X AXIS
C      NYSTP = SUBGRID DIV. IN Y AXIS
C              1 GIVES 10 SUBGD.
C      NXSTP = SUBGRID DIV. IN X AXIS
C              2 GIVES  1 SUBGD.
C      YMINV = MIN VAL IN Y AXIS
C      YMAXV = MAX VAL IN Y AXIS
C      XMINV = MIN VAL IN X AXIS
C      XMAXV = MAX VAL IN X AXIS
C      FIELD 4I10,4E10.5
       DIMENSION RS(10,100),XJ(10,100),Q(10,100),TIME(10,100)
       DIMENSION XI(10,100)
       DIMENSION IX(5),IY(5),IL(2),XO(10,100)
C   ***  READ IN DATA
       READ 100,NPLT,NSTP1,NSTP2,NSTP3,NSTP4,NSTP5
       DO 10 I=1,NPLT
       IF(I.EQ.1) NSTP=NSTP1
       IF(I.EQ.2) NSTP=NSTP2
       IF(I.EQ.3) NSTP=NSTP3
       IF(I.EQ.4) NSTP=NSTP4
       IF(I.EQ.5) NSTP=NSTP5
       DO 10 J=1,NSTP
       READ(14,104) JMAXI,IAMBNT
       READ(14,101) TEMP,TMAX,DELT,DFLY,YDIST
    10 READ(14,101) RS(I,J),XI(I,J),XJ(I,J),Q(I,J),TIME(I,J),XO(I,J)
       IF(IAMBNT.EQ.1) IL(1)='DRY OX'
       IF(IAMBNT.EQ.1) IL(2)='YGEN  '
       IF(IAMBNT.EQ.2) IL(1)='STEAM '
       IF(IAMBNT.EQ.2) IL(2)='      '
       IF(IAMBNT.EQ.3) IL(1)='NITROG'
       IF(IAMBNT.EQ.3) IL(2)='EN    '
C
   100 FORMAT(8I10)
   101 FORMAT(1H0,6E15.9)
   102 FORMAT(2(5A6),2I10)
   103 FORMAT(4I10,4E10.5)
   104 FORMAT(1H0,8I10)
   105 FORMAT(2A6)
   400 FORMAT(1H0,10X,'XMIN = ',5X,'XMAX = ',5X 'YMIN = ',5X 'YMAX = ',
      *//1H0,3X,4(F10.5,3X))
C
       DATA HGT,XMAX,YMAX/0.0875,7.,5./
       TMAX=TMAX/60.
       IC=10
C   ***  INITIATE THE PLOT
       DO 11 N=1,3
       READ 102, (IX(I),I=1,5),(IY(I),I=1,5),JCOD
       READ 103, IGRID,JGRID,NYSTP,NXSTP,YMINV,YMAXV,XMINV,XMAXV
       PRINT 400,XMINV,XMAXV,YMINV,YMAXV
       IF(JCOD.NE.0) ICON=2
       IF(JCOD.EQ.0) ICON=3
       CALL PLOTS(10,0,10,3)
       CALL PLOT (1.5,1.0,-3)
C   ***  DRAW BORDER
       CALL PLOT(0.0,YMAX,2,-1)
       CALL PLOT(XMAX,YMAX,2,-1)
       CALL PLOT(XMAX,0.0,2,-1)
       CALL PLOT(0.0,0.0,2,-1)
C   ***  DRAW GRID
       YDIV=YMAX/FLOAT(JGRID)
       JK=1
       DO 12 I=1,JGRID
       DO 13 J=1,IC,NYSTP
       YSPC=ALOG10(FLOAT(J*JK))*YDIV
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      CALL PLOT(0.0,YSPC,3)
      CALL PLOT(0.12,YSPC,2,0)
      CALL PLOT(XMAX-0.12,YSPC,ICOD)
   13 CALL PLOT(XMAX,YSPC,2,0)
   12 JK=JK*10
      IGRID1=IGRID*NXSTP
      IGRID2=IGRID1-1
      XDIV=XMAX/FLOAT(IGRID1)
      DO 14 I=1,IGRID2
      XSPC=FLOAT(I)*XDIV
      CALL PLOT(XSPC,0.0,3).
      CALL PLOT(XSPC,0.12,2,0)
      CALL PLOT(XSPC,YMAX-0.12,ICOD)
   14 CALL PLOT(XSPC,YMAX,2,0)
C  ***  AXES NUMBERS
      VAL1=YMINV
      JK=1
      JGRD1=JGRID+1
      DO 16 I=1,JGRD1
      DO 17 J=1,IC,NYSTP
      IF(I.EQ.JGRD1.AND.J.NE.1) GO TO 17
      YSPC=ALOG10(FLOAT(J*JK))*YDIV
      YSPC1=YSPC
      IF(J.EQ.1) GO TO 200
      VAL=FLOAT(J)
      CALL NUMBER(-0.18,YSPC1,.08,VAL,0.,-1)
      GO TO 17
  200 VAL2=ALOG10(VAL1)
      CALL NUMBER(-0.56,YSPC1,0.10,10.,0.,-1)
      CALL NUMBER(-0.36,YSPC1+.09,0.1,VAL2,0.,-1)
   17 CONTINUE
      VAL1=VAL1*10.
   16 JK=JK*10
      XV=XMAXV/FLOAT(IGRID)
      IGRID3=IGRID+1
      DO 18 I=1,IGRID3
      XSPC=(I-1)*XDIV*NXSTP
      XSPC1=XSPC-0.2
      VAL=XV*(I-1)
   18 CALL NUMBER(XSPC1,-0.20,0.1,VAL,0.0,2)
C  ***  PUT LABELS
      CALL SYMBOL(-0.8,1.0,0.1313,IY,90.,30)
      CALL SYMBOL(2.00,-0.50,0.1313,IX,0.,30)
      CALL SYMBOL(2.0,5.5,HGT,'TEMP = ',0.,7)
      CALL NUMBER(3.0,5.5,HGT,TEMP,0.,1)
      CALL SYMBOL(2.0,5.3,HGT,'NORMALIZING TIME =          MIN',
     * 0.0,32)
      CALL NUMBER(3.6,5.3,HGT,TMAX,0.,1)
      CALL SYMBOL(2.0,5.1,HGT,'AMBIENT = ',0.,10)
      CALL SYMBOL(3.0,5.1,HGT,IL,0.,12)
      IF(N.EQ.2) CALL SYMBOL(4.5,5.5,HGT,'THICKNESS =        CM-4',
     * 0.0,23)
      IF(N.EQ.2) CALL NUMBER(5.6,5.5,HGT,YDIST,0.,1)
C  ***  DRAW CURVES
      YLOG=YMAX/FLOAT(JGRID)
      XV1=XMAX/XMAXV
      YMVR=1./YMINV
      DO 22 I=1,NPLT
      CALL PLOT(0.0,0.0,3)
      IF(I.EQ.1) NSTP=NSTP1
      IF(I.EQ.2) NSTP=NSTP2
      IF(I.EQ.3) NSTP=NSTP3
      IF(I.EQ.4) NSTP=NSTP4
      IF(I.EQ.5) NSTP=NSTP5
      DO 21 J=1,NSTP
      IF(J.EQ.1) L=3
      IF(J.NE.1) L=2
      IF(IAMBNT.NE.3) TIME(I,J)=TIME(I,J)/TIME(NPLT,NSTP)
      XMOVE= TIME(I,J)*XV1
      IF(N.EQ.3) GO TO 201
      IF(N.EQ.2) GO TO 202
      YMOVE=YLOG*ALOG10(RS(I,J)*YMVR)
      GO TO 21
  201 YMOVE=YLOG*ALOG10(Q(I,J)*YMVR)
      GO TO 21
  202 YMOVE=YLOG*ALOG10(XJ(I,J)*YMVR)
   21 CALL PLOT(XMOVE,YMOVE,L,0)
      IF(N.NE.2) GO TO 22
      CALL PLOT(0.0,0.0,3)
      DO 23 J=1,NSTP
```

```
      IF(J.EQ.1) L=3
      IF(J.NE.1) L=2
      XMOVE=TIME(I,J)*XV1
      XI(I,J)=XI(I,J)*(YDIST-0.45*XO(I,J))/1.E-4
      IF(XI(I,J).LT.1.E-01) XI(I,J)=1.E-01
      YMOVE=YLOG*ALOG10(XI(I,J)*YMVR)
   23 CALL PLOT(XMOVE,YMOVE,L,0)
   22 CONTINUE
      CALL PLOT(0.,0.,999)
   11 CONTINUE
      STOP
      END
```

```
!!CRON*SnS2(1).PARAM
      SUBROUTINE PARAM(CI,T)
C************************************************************************
C          AFTER THAI AND MORIN AND MAITA.
C************************************************************************
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      CI=1.E15
    2 EG=1.21+7.1E-10*SQRT(CI)*(T)**(-.5)
      EG=EG/(8.62E-5*(T))
      CIOLD=CI
      CI=3.87E16*((T)**(1.5))*EXP(-EG/2.)
      R=CIOLD/CI
      IF(R.LT.0.995.AND.R.GT.1.005) GO TO 2
      RETURN
      END
C************************************************************************
```

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MICRON.SnS2(1).G

```
      DOUBLE PRECISION FUNCTION G(CN,JJ)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
C**********************************************************************
C          IRWIN'S CONDUCTIVITY FORMULAS.
C**********************************************************************
      IF(JJ.EQ.1) GO TO 3
      IF(CN.GT.0.0) A=1.0
      IF(CN.GT.0.0) B=7.2D-17
      IF(CN.GT.1.6D +16) A=0.65
      IF(CN.GT.1.6D +16)B=3.3D-11
      IF(CN.GT.2.4D+18) A=0.832
      IF(CN.GT.2.4D+18)B=1.47D-14
      IF(CN.GT.1.5D+19) A=0.966
      IF(CN.GT.1.5D+19)B=4.D-17
      GO TO 5
    3 IF(CN.GT.0.0) A=1.0
      IF(CN.GT.0.0)B=2.D-16
      IF(CN.GT.3.5D15)A=0.837
      IF(CN.GT.3.5D15)B=6.97D-14
      IF(CN.GT.1.0D17) A=0.543
      IF(CN.GT.1.0D17)B=6.93D-9
      IF(CN.GT.9.5D18) A=0.94
      IF(CN.GT.9.5D18)B=2.D-16
      IF(CN.GT.6. D19) A=0.744
      IF(CN.GT.6. D19)B=1.43D-12
      IF(CN.GT.2.35D20)A=0.456
      IF(CN.GT.2.35D20) B=1.04D-6
    5 G = B*(CN**A)
      RETURN
      END
```

```
IICRON*SnS2(1).OXDATA
              SUBROUTINE OXDATA(AMANT,ORINT,T,A,C,M,KB)
       C**********************************************************************
       C
       C          SUBROUTINE FOR OXIDATION PARAMETERS AND SEGREGATION CO-EFFI.
       C**********************************************************************
       C
              IMPLICIT DOUBLE PRECISION(A-H,O-Z)
              INTEGER AMBNT,ORINT
              DOUBLE PRECISION KB,M,M1,M3
       C
              IF(AMANT.EQ.1) GO TO 12
              A=4.40277D-10*DEXP(-7945.74/T)
              IF(ORINT.EQ.1) C=6.94558D-1*DEXP(-22184.07/T)
              IF(ORINT.EQ.2) C=9.13546D-1*DEXP(-21835.313/T)
              IF(ORINT.EQ.3) C=1.60D0*DEXP(-22396.838/T)
              GO TO 14
          12  CONTINUE
              A=1.58507D-9*DEXP(-13916.6449/T)
              IF(ORINT.EQ.1) C=2.0093D-1*DEXP(-24118.9A/T)
              IF(ORINT.EQ.2) C=4.33277D-1*DEXP(-24551.98/T)
              IF(ORINT.EQ.3) C=7.09845D-1*DEXP(-24957.028/T)
          14  CONTINUE
              M1=33.3*DEXP(-0.52/(KB*T))
              M3=20.0*DEXP(-0.52/(KB*T))
              IF(ORINT.EQ.1) M=M1
              IF(ORINT.EQ.2) M=(M1+M3)/2.0
              IF(ORINT.EQ.3) M=M3
              RETURN
              END
```

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```
      SUBROUTINE FRONT(IMAXI,JMAXI,LM,K,TEMP,DFI,DELT,JSTEP,
     *  KTYPE,KOTI,XDIST)
C
C     SUB. FOR CALCULATING CONTOUR FRONT MOVEMENT DATA AND
C     READING AND WRITING THE SAME ON FILE
C
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      DIMENSION XFRONT(6), YFRONT(6)
      DATA IDOL,IBLNK,ISTAR/1H$,1H ,1H*/
      IF(KTYPE.NE.1) GO TO 800
C
C     READ FILE
C
      DO 60 KK=1,JSTEP
         READ (9,390) MARK
         IF (MARK.NE.IDOL) GO TO 50
      READ(9,430) TEMP,DFI,DELT
      READ(9,390) MARK
   50    READ (9,430) (DUM,L=1,6)
         READ (9,430) (DUM,L=1,6)
      READ(9,420) IMAXI,JMAXI,K,LM
   60    CONTINUE
      RETURN
  800 CONTINUE
      DO 260 LL=1,6
         CONVAL=10.0**FLOAT(20-LL+1)
         XF=CONDEF(IMAXI,JMAXI,0,-JMAXI,0,0,CONVAL)
      YF=CONDEF(IMAXI,JMAXI,-2,0,0,0,CONVAL)
         IF (XF.EQ.0.0) GO TO 250
         XFRONT(LL)=(XF-FLOAT(K))*(XDIST/FLOAT(IMAXI-1))
  250    CONTINUE
         IF (YF.EQ.0.0) GO TO 260
         YFRONT(LL)=(FLOAT(JMAXI)-YF)/FLOAT(JMAXI-1)
  260    CONTINUE
C
C        STORE CONTOUR FRONT MOVEMENT DATA IF IFILE = 1
C
      MARK=IDOL
      IF (KOTI.GT.1) MARK=IBLNK
      WRITE (9,390) MARK
      IF (KOTI.GT.1) GO TO 270
      WRITE(9,430) TEMP,DFI,DELT
      MARK=IBLNK
      WRITE(9,390) MARK
  270 WRITE (9,430) (XFRONT(LL),LL=1,6)
      WRITE (9,430) (YFRONT(LL),LL=1,6)
      WRITE(9,420) IMAXI,JMAXI,K,LM
  390 FORMAT (1H0,A6)
  400 FORMAT (1H ,3F10.3)
  420 FORMAT (1H ,4I5)
  430 FORMAT (1H ,6(E14.9,2X))
      RETURN
      END
```

```
IICRON*S0S2(1).FRPLOT
      C  *** PLOT PROGRAM FOR THE CONTOUR FRONT MOVEMENT ***
      C
      C             READ IN FROM DATA DECK
      C        JSTEP= # OF TIME STEPS TO BE READ IN
      C
      C          'TEMP - SIMULATION TEMPERATURE',
      C                   'DFI = LAMDA**2',
      C                   'DLT - TIME STEP',
      C
            DOUBLE PRECISION XFRONT(800,6),YFRONT(800,6)
            DOUBLE PRECISION TEMP,DFI,DLT
            DIMENSION TAU(800)
            DIMENSION IX(3),IY(3),IA(6)
            DATA IDOL,IBLNK,ISTAR/1H$,1H ,1H*/
            DATA IA/6HCONCEN,6HTRATIO,6HN FRON,6HT MOVE,6HMENT P,6HLOT   /
            DATA IX/6HIN X D,6HIRECTI,6HON    /
            DATA IY/6HIN Y D,6HIRECTI,6HON    /
        390 FORMAT(1HO,A6)
        420 FORMAT(1H ,4I5)
        430 FORMAT(1H ,6(E14.9,2X))
      C  ***  READ DATA FROM DECK
            READ 200, JSTEP
        200 FORMAT(8I10)
            TIME=0.
            DO 1 KK=1,JSTEP
            READ(8,390) MARK
            IF(MARK.NE.IDOL) GO TO 5
            READ(8,430) TEMP,DFI,DLT
            READ(8,390) MARK
          5 READ(8,430) (XFRONT(KK,LL),LL=1,6)
            READ(8,430) (YFRONT(KK,LL),LL=1,6)
            READ(8,420) IMAX1,JMAX1,LM
            TIME=TIME+DLT
            TAU(KK)=TIME
          1 CONTINUE
            DATA HGT,XMAX,YMAX/0.0875,7.0,5.0/
      C  ***  INITIATE THE PLOT
            DO 80 N=1,2
            CALL PLOTS(10.0,10.0)
            CALL PLOT(1.5,1.5,-3)
      C  ***  DRAW BORDER
            CALL PLOT(0.0,YMAX,2,-1)
            CALL PLOT(XMAX,YMAX,2,-1)
            CALL PLOT(XMAX,0.0,2,-1)
            CALL PLOT(0.0,0.0,2,-1)
      C  ***  SCALE GRID
            TTAU=TAU(JSTEP)*100.
            IDIV=INT(TTAU)
            IS=IDIV/25*25+25
            TAUM=FLOAT(IS)/100.
      C
            YY1=XFRONT(1,6)
            IF(N.EQ.2) YY1=YFRONT(1,6)
            DO 2 I=2,JSTEP
            YY2=XFRONT(I,6)
            IF(N.EQ.2) YY2=YFRONT(I,6)
            YYY=AMAX1(YY1,YY2)
          2 YY1=YYY
            YAP=YYY*100.
            IYD=INT(YAP)
            IT=IYD/25*25+25
            YDMAX=FLOAT(IT)/100.
      C  ***  DRAW GRID
            DX=XMAX/20.
            DO 10 I=1,19
            X=FLOAT(I)*DX
            CALL PLOT(X,0.,3)
            CALL PLOT(X,YMAX,2,1)
         10 CONTINUE
            DY=YMAX/20.
            DO 20 J=1,19
            Y=FLOAT(J)*DY
            CALL PLOT(0.0,Y,3)
            CALL PLOT(XMAX,Y,2,1)
         20 CONTINUE
      C  ***  ERASE LABLE AREA
            DO 30 I=3,14
            XX=(I-1)*DX
            CALL PLOT(XX,17.*DY,3)
```

```
   30 CALL PLOT(XX,19.5*DY,12)
      DO 40 I=19,20
      YY=(I-1)*DY
      CALL PLOT(DX,YY,3)
   40 CALL PLOT(14.*DX,YY,12)
C  ...  PUT SYMBOL
      CALL SYMBOL(0.5,4.7,0.1313,IA,0.0,33)
      IF(N.EQ.2) IX=IY
      CALL SYMBOL(1.6,4.45,0.1313,IX,0.0,14)
C  ...  AXES NUMBERS
      Y=-0.2
      DO 50 I=1,11
      X=FLOAT(I-1)*2.*DX-.125
      VAL=FLOAT(I-1)*TAUM/10.
   50 CALL NUMBER(X,Y,HGT,VAL,0.0,2)
      X=-0.5
      DO 60 J=1,21
      Y=FLOAT(J-1)*DY-.063
      VAL=FLOAT(J-1)*YDMAX/20.
   60 CALL NUMBER(X,Y,HGT,VAL,0.0,2)
      CALL SYMBOL(-.75,2.,.1313,'DISTANCE',90.,8)
      CALL SYMBOL(2.,-.5,.1313,'NORMALIZED TIME - TAU',0.,21)
      DO 70 LL=1,6
      CALL PLOT(0.0,0.0,3)
      XMOVE=0.
      CALL PLOT(TAU,XMOVE,2,0)
      DO 70 ML=1,JSTEP
      TAUP=TAU(ML)*XMAX/TAUM
      XMOVE=XFRONT(ML,LL) *YMAX/YDMAX
      IF(N.EQ.2) YMOVE=YFRONT(ML,LL)*YMAX/YDMAX
      IF(TAU.GT.0.0.AND.YMOVE.EQ.0.0.AND.N.EQ.2) GO TO 70
      IF(N.EQ.2) XMOVE=YMOVE
      IF(XMOVE.LT.0.) XMOVE=0.0
      CALL PLOT(TAUP,XMOVE,2,0)
   70 CONTINUE
      CALL PLOT(0.,0.,999)
   80 CONTINUE
      STOP
      END
```

```
IICRON*SOS2(1).SHFILE
              SUBROUTINE SHFILE(TIME,DELT,DELY,TEMP,TMAX,RS,YJI,YJUNC,Q
             *  ,JMAXI,YDIST,XO,IAMANT)
        C
        C    SUB WRITES SEET RESISTANCE, JUNCTION DEPTH AND INTIGRATED
        C    IMPURITY ON UNIT 13
        C
              IMPLICIT DOUBLE PRECISION(A-H,O-Z)
              WRITE(13,200) JMAXI,IAMANT
          200 FORMAT(1H0,8I10)
              WRITE(13,100) TEMP,TMAX,DELT,DELY,YDIST
              WRITE(13,100) RS,YJI,YJUNC,Q,TIME,XO
          100 FORMAT(1H0,6E15.9)
              RETURN
              END
```

```
MICRON*SOS2(1).OUTPUT
         SUBROUTINE OUTPUT(X,Y,IMAX1,JMAX1,K,LM,JJ,TIME,YDIST,
        *ID,ITIME,XO,PTIME,DTIME,IAMBNT)
C
C     TRANSIENT DATA PRINT OUT
C
         IMPLICIT DOUBLE PRECISION(A-H,O-Z)
         COMMON /CON/CB1(64,64)
         DIMENSION X(1),Y(1),ID(15),XO(1)
         IMAX=IMAX1-1
         IMAX2=IMAX1+1
         PRINT 106, ID,ITIME
         PRINT 100, LM,TIME,PTIME,DTIME,K,X(K),IMAX1,X(IMAX1)
         PRINT 101, (N,N=2,IMAX1,2)
         PRINT 102, (X(I),I=2,IMAX1,2)
         PRINT 105
         WI=YDIST-0.45*XO(2)
         DO 2 J=JMAX1,1,-1
         Q=YDIST-Y(J)
         IF(IAMBNT.NE.3) Q=(JMAX1-J)*(1./FLOAT(JMAX1-1))
    2    PRINT 103, Q,(CB1(I,J),I=2,IMAX1,2)
         PRINT 108, (XO(I),I=2,IMAX1,2)
         IF(IAMBNT.NE.3) PRINT 109, WI
  109    FORMAT(/1H0,10X,'* SI FILM * = ',E10.5)
  108    FORMAT(1H0,10X,'* OXIDE THICKNESS IN CM *'/1H0,13X,11(1PE10.3))
         PRINT 104, JJ
  100    FORMAT(1H0,10X,12HTIME STEP = ,I4,3X,7HTIME = ,F10.3,
        *5X,'ELAPSED TIME IN SEC.:',2X,'PREDEP = ',F10.3,2X,'DRIVE IN = ',
        *  F10.3//
        *10X,'OXIDE POSITION'/
        *10X,'X(',I2,') = ',E6.2,2X,'X(',I2,') = ',E6.2//)
  101    FORMAT(//,1H0,   3HI = ,6X,12I10)
  102    FORMAT (/,1H0,3X,3HX = ,7X,12(1PE10.3))
  103    FORMAT(1H, 2X,'Y=',1PF7.1,2X,11(1PE10.3))
  104    FORMAT(//,1H0,'NO. OF ITERATION = ',I5)
  105    FORMAT(1H0)
  106    FORMAT(1H1,10X,15A4,T98,'TIME',A6)
         RETURN
         END

PRT SOS2.PLOT-CONTOUR,,SUBION,,TRIDAG,,ABC,,XYZ,,PLOT,,CONDEP,,MAIN
```

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```
1ICRON*SOS2(1).PLOT=CONTOUR
      SUBROUTINE PLTCON(A,CONVAL,NC,IK,JK)
C
C     ISOCONCENTRATION PLOT SUBPROGRAM /
C
      DIMENSION A(64,64),X(1000,3),Y(1000,3),NV(1000)
      DIMENSION CS(2,3),CT(2,2,4),OT(2,4),B(4),OS(2,3)
      DATA ZERO/1.0E-20/
      DATA ((CS(I,J),J=1,3),I=1,2)/0.5,-1.0,0.5,-0.5,0.0,0.5/
      DATA (((CT(I,J,K),K=1,4),J=1,2),I=1,2)/1.0,0.0,-1.0,0.0,0.0,1.0,
     *0.0,-1.0,0.0,-1.0,0.0,1.0,1.0,0.0,-1.0,0.0/
      DATA ((OT(I,J),J=1,4),I=1,2)/0.0,0.0,1.0,1.0,0.0,0.0,1.0,1.0,0.0,0.0/
      DATA ((OS(I,J),J=1,3),I=1,2)/0.5,1.0,0.0,0.5,0.0,0.0/
      DATA XMAX,YMAX/8.0,4.0/
      NCM1=NC-1
      CONTUR=ALOG10(CONVAL)
C*    * RESET PEN TO ORIGIN
      CALL PLOT(0.0,0.0,3)
C*    * COMPUTE SCALING FACTORS
      SCALX=XMAX*1.5/(IK-2)
      SCALY=YMAX/(JK-1)
C*    * START CONTOUR SEARCH
      NT=0
      IL=IK-1
      JL=JK-1
   10 DO 50 I=2,IL
      DO 50 J=1,JL
C*    * LOCATE SQUARE CROSSINGS
      II=I-2
      JJ=J-1
      B(1)=0.25*(ALOG10(A(I,J))+ALOG10(A(I+1,J))+ALOG10(A(I,J+1))+
     *ALOG10(A(I+1,J+1)))
      B(1)=10.0**B(1)
      B(4)=B(1)
C*    * LOCATE TRIANGLES
   20 DO 40 K=1,4
      NP=0
      GO TO (21,22,23,24),K
   21 B(2)=A(I+1,J)
      B(3)=A(I,J)
      GO TO 30
   22 B(2)=A(I,J)
      B(3)=A(I,J+1)
      GO TO 30
   23 B(2)=A(I,J+1)
      B(3)=A(I+1,J+1)
      GO TO 30
   24 B(2)=A(I+1,J+1)
      B(3)=A(I+1,J)
      GO TO 30
C*    * LOCATE INTERSECTIONS
   30 DO 35 M=1,3
      IF (CONVAL.LT.AMIN1(B(M),B(M+1)).OR.CONVAL.GT.AMAX1(B(M),B(M+1)))
     * GO TO 35
      NP=NP+1
      BB=ALOG10(B(M+1))-ALOG10(B(M))
      IF (ABS(BB).GT.ZERO) GO TO 33
      D=0.5
      GO TO 34
   33 D=(CONTUR-ALOG10(B(M)))/BB
   34 CONTINUE
      TX=OS(1,M)+CS(1,M)*D
      TY=OS(2,M)+CS(2,M)*D
      X(NT+1,NP)=OT(1,K)+CT(1,1,K)*TX+CT(1,2,K)*TY+II
      Y(NT+1,NP)=OT(2,K)+CT(2,1,K)*TX+CT(2,2,K)*TY+JJ
   35 CONTINUE
      IF (NP.LE.1) GO TO 40
      NT=NT+1
      NV(NT)=NP
   40 CONTINUE
   50 CONTINUE
C*    * SCALE POINTS
      IF (NT.EQ.0) GO TO 80
   60 DO 65 K=1,NT
      NM=NV(K)
      DO 65 L=1,NM
      X(K,L)=X(K,L)*SCALX
      Y(K,L)=Y(K,L)*SCALY
   65 CONTINUE
C*    * PLOT CONTOUR
```

```
      DO 71 K=1,NT
      NM=NV(K)
      CALL PLOT(X(K,1),Y(K,1),3)
      IF (MOD(K,10).EQ.0) CALL SYMBOL(X(K,1),Y(K,1),0.10,NCH,0.0,-1)
      DO 71 L=2,NM
      CALL PLOT(X(K,L),Y(K,L),2)
      IF (NM.EQ.3) CALL PLOT(X(K,1),Y(K,1),2)
   71 CONTINUE
C*    9 MOVE PEN TO ORIGIN
   80 CALL PLOT(0.0,0.0,3)
      RETURN
      END
```

```
MICRON*SOS2(1).TRIDAG
      SUBROUTINE TRIDAG(JF,L)
C**********************************************************************************
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      COMMON /TRI/ A(64),B(64),C(64),D(64),V(64)
C
      DIMENSION GAMMA(64),BETA(64)
      BETA(JF)=B(JF)
      GAMMA(JF)=D(JF)/BETA(JF)
      JFP1=JF+1
      DO 100 I=JFP1,L
      BETA(I)=B(I)-A(I)*C(I-1)/BETA(I-1)
  100 GAMMA(I)=(D(I)-A(I)*GAMMA(I-1))/BETA(I)
      LAST=L-JF
      V(L)=GAMMA(L)
      DO 200 K=1,LAST
      I=L-K
  200 V(I)=GAMMA(I)-C(I)*V(I+1)/BETA(I)
      RETURN
      END
```

```
MICRON*SNS2(1).SUBION
      SUBROUTINE SUBION(IMAX1,JMAX1,K,Y,YDIST,CSTOP)
C*********************************************************************
C     SUBROUTINE FOR GENERATING ION IMPLANT DATA
C*********************************************************************
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      COMMON /CON/CB1(64,64)
      DIMENSION Y(1)
      ISS=0
      JM=JMAX1/2
      IF(Y(JM).LT.1.D-3) ISS=1
      READ 100, CMAX,RP,DRP,VOLT
  100 FORMAT(3E15.6,F10.5)
      PRINT 200, CMAX,RP,DRP,VOLT,CSTOP
  200 FORMAT(//1H0,'CMAX = ',E10.5,' CM-3',3X,'RP = ',E10.5,' MICRON'/
     *  1H ,'DRP = ',E10.5,' MICRON' /1H ,'ION IMPLANTATION WITH
     *  BORON IMPLANT AT',F10.5,' KEV',5X,'CSTOP = ',E15.6)
      IF(ISS.EQ.1) RP=RP*1.D-4
      IF(ISS.EQ.1) DRP=DRP*1.D-4
      DO 1 J=1,JMAX1
    1 CB1(1,J)=CMAX*DEXP(-0.5*((YDIST-Y(J)-RP)/DRP)**2)
      DO 2 J=1,JMAX1
      DO 3 I=2,K
    3 CB1(I,J)=CB1(1,J)
    2 CONTINUE
      RETURN
      END
```

```
MICRON*SNS2(1).ABC
      SUBROUTINE ABC(IMAX1,JMAX1,X,Y,LM,TIME,K,DFI,TEMP,TMAX,KOTI,XO,
     *  YDIST,IAMNT)
C*********************************************************************
C**                                                                 **
C**  SUBROUTINE WRITES TRANSIENT DATA ON DATA FILE ON UNIT 11       **
C**                                                                 **
C*********************************************************************
      DOUBLE PRECISION CB1,X,Y,TIME,TEMP,TMAX,DFI,XO,YDIST
      COMMON /CON/CB1(64,64)
      DIMENSION XO(1)
      DIMENSION X(1),Y(1)
      DATA IDOL,IBLNK/1H$,1H /
      KOTI=KOTI+1
      MARK=IDOL
      IF(KOTI.GT.1) MARK=IBLNK
      WRITE(11,400) MARK
  400 FORMAT(1H0,A6)
      IF(KOTI.GT.1) GO TO 2
      WRITE(11,100) DFI,TMAX,TEMP,YDIST
      WRITE(11,200)K,IMAX1,JMAX1,IAMNT
  200 FORMAT(1H ,8I10)
      WRITE(11,100) (X(I),I=2,IMAX1)
      WRITE(11,100) (Y(I),I=1,JMAX1)
      MARK=IBLNK
      WRITE(11,400) MARK
    2 CONTINUE
      WRITE(11,200) LM
      WRITE(11,100) TIME
      DO 1 J=JMAX1,1,-1
    1 WRITE(11,100) (CB1(I,J),I=2,IMAX1)
      WRITE(11,100) (XO(I),I=2,IMAX1)
  100 FORMAT(1H ,5E15.9)
      PRINT 300, KOTI
  300 FORMAT(1H0,10X,'KOTI = ',I10/)
      RETURN
      END
```

```
MICRON*SOS2(1).XYZ
      SUBROUTINE XYZ(IMAX1,JMAX1,X,Y,LM,TIME,K,DFI,TEMP,THAX,KOTI,XO,
     *  YDIST,IAMANT)
C*************************************************************
C
C     SUBROUTINE READS THE TRANSIENT DATA FILE ON UNIT 11
C
      DOUBLE PRECISION CBI,X,Y,TIME,TEMP,THAX,DFI,XO,YDIST
      COMMON /CON/CBI(64,64)
      DIMENSION XO(1)
      DIMENSION X(1),Y(1)
      DATA IDOL,IBLNK/1H$,1H /
      DO 3 KLM=1,KOTI
      READ (11,400) MARK
      IF(MARK.NE.IDOL) GO TO 5
      READ(11,100) DFI,THAX,TEMP,YDIST
      READ(11,200) K,IMAX1,JMAX1,IAMBNT
  100 FORMAT(1H ,5E15.9)
  200 FORMAT(1H ,8I10)
      READ(11,100) (X(I),I=2,IMAX1)
      READ(11,100) (Y(I),I=1,JMAX1)
      READ(11,100) MARK
    5 CONTINUE
      READ(11,200) LM
      READ(11,100) TIME
      DO 1 J=JMAX1,1,-1
    1 READ(11,100) (CBI(I,J),I=2,IMAX1)
      READ(11,100) (XO(I),I=2,IMAX1)
    3 CONTINUE
  400 FORMAT(1H0,A6)
C     APPLY PERIODIC B.C.
      IMAX2=IMAX1+1
      IMAX =IMAX1-1
      DO 7 J=1,JMAX1
      CBI(1,J)=CBI(3,J)
    7 CBI(IMAX2,J)=CBI(IMAX,J)
      RETURN
      END
```

MICRON*SnS2(1).PLOT

```
      SUBROUTINE PLOT(CS,IMAX1,JMAX1,N)
C*****************************************************************
C
C     SUBROUTINE PLOTS THE TWO DIMENSIONAL PROFILE
C     IN THE OUTTPUT PRINTOUT IF IPLOT = 1
C
C*****************************************************************
      DOUBLE PRECISION CB1,CS
      COMMON /CON/CB1(64,64)
      DIMENSION SYMBL(21),ULINE(43)
      DIMENSION IX(32)
      DATA SYMBL/1HA,1H ,1HB,1H ,1HC,1H ,1HD,1H ,1HE,1H ,1HF,1H ,
     *1HG,1H ,1HH,1H ,1HI,1H ,1HJ,1H ,1HK/
      DATA DOT,STAR/1H.,1H*/,KP/21/
      DATA IX/6*1H ,  1HY,1H ,1HA,1HX,1HI,1HS,20*1H /
      IMAX=IMAX1-1
      PRINT 11
      AT=ALOG10(2.2D11)
      FACT=(ALOG10(CS)-AT)/(FLOAT(KP-1))
      K=0
      DO 2 J=JMAX1,1,-1
      DO 1 I=2,IMAX1
      IF(CB1(I,J).LE.0.0) GO TO 3
      K=((ALOG10(CB1(I,J))-AT)/FACT)+1.0
    3 CONTINUE
      IF(K.LT.1) ULINE(I)=DOT
      IF(K.GE.1.AND.K.LE.KP) ULINE(I)=SYMBL(K)
    1 IF(K.GT.KP) ULINE(I)=STAR
      L=JMAX1+1-J
    2 PRINT 10,IX(L), (ULINE(I),I=2,IMA  ),(ULINE(I),I=IMAX,2,-1)
      PRINT 12
      PRINT 13
      PRINT 14,SYMBL(KP),CS
      KD=KP-1
      DO 4 I=KD,1,-1
      CBL=10.**((I-1)*FACT+AT)
      CBH=10.**(I*FACT+AT)
    4 PRINT 15, SYMBL(I),CBH,CBL
      PRINT 16
   10 FORMAT(1H ,A1,1X,1H1,70A1)
   11 FORMAT(1H1,'IMPURITY CONCENTRATION PROFILE'/
     *1H0,41(1H*),///)
   12 FORMAT(1H ,1X,50(1H-)//1H ,15X,'X AXIS')
   13 FORMAT( /,1H0,'SYMBOLIC REPRESENTATION OF CONCENTRATION RANGES'
     *//1H0,T10,'SYMBOL',T30,'CONCENTRATION RANGE'/1H ,T10,6(1H-),T30,
     *19(1H-)/ 1H0,T13,1H*,T29,'ABOVE SURFACE CONC.')
   14 FORMAT(1H ,T13,A1,T29,'AT CS = ',E10.3)
   15 FORMAT(1H ,T13,A1,3X,'LESS THAN',E10.3,3X,'GREATER THAN OR EQUAL T
     *O',E10.3)
   16 FORMAT(1H ,T13,1H.,T29,'BELOW 1.00E11')
      RETURN
      END
```

MICRON*SOS2(1).CONDEP

```
      FUNCTION CONDEP(M,N,I,J,MIN,MAX,CONVAL)
C*    * LOCATES CONCENTRATION CONTOURS ALONG EITHER        *
C*    * A VERTICAL OR HORIZONTAL GRID LINE. EITHER         *
C*    * LINEAR OR LOGRITHIMIC INVERSE INTERPOLATION        *
C*    * CAN BE USED.                                       *
C*    *                                                    *
C*    * A       -  ARRAY BEING CONTOURED (DIMENSIONED      *
C*    *            (M,N) IN CALLING PROGRAM                *
C*    *                                                    *
C*    * I,J     -  NON-ZERO VALUE SPECIFIES GRID LINE      *
C*    *            TO BE CONTOURED. POSITIVE VALUE FOR     *
C*    *            LINEAR INTERPOLATION, NEGATIVE FOR      *
C*    *            LOGRITHIOMIC INTERPOLATION. EITHER      *
C*    *            I OR J MUST BE ZERO.                    *
C*    * CONVAL-    CONOUR VALUE                            *
C*    *                                                    *
C*    * MIN,    -  MINIMUM AND MAXIMUM SUBSCRIPTS OF       *
C*    * MAX        GRID LINE TO BE CONTOURED. (MAY BE      *
C*    *            ZERO IF ENTIRE GRID LINE IS TO BE       *
C*    *            CONTOURED.)                             *
C*    * CONDEP-    POSITION OF CONVAL ON GRID LINE. IF     *
C*    *            CONVAL IS OUT OF RANGE OF GRID LINE     *
C*    *            VALUES CONDEP RETURNS A VALUE OF        *
C*    *            ZERO.                                   *
C*    *                                                    *
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      COMMON /CON/A(64,64)
      DO 100 I=1,M
      DO 100 J=1,N
  100 IF(A(I,J).LT.1.D-100) A(I,J)=1.D-100
      ILOG=1
      IF (I.NE.0) GO TO 10
      IINC=1
      IMIN=MIN
      IMAX=MAX-1
      IF ( MIN.EQ.0) IMIN=1
      IF ( MAX.EQ.0) IMAX=M-1
      IF (J.LT.0) ILOG=-1
      JINC =0
      JMIN=IABS(J)
      JMAX=JMIN
      GO TO 20
   10 CONTINUE
      JINC=1
      JMIN=MIN
      JMAX=MAX-1
      IF ( MIN.EQ.0) JMIN=1
      IF ( MAX.EQ.0) JMAX=N-1
      IF (I.LT.0) ILOG=-1
      IINC=0
      IMIN=IABS(I)
      IMAX=IMIN
   20 CONTINUE
      CONDEP=0.0
      DO 45 II=IMIN,IMAX
      DO 40 JJ=JMIN,JMAX
      IF(CONVAL.LT.AMIN1(A(II,JJ),A(II+IINC,JJ+JINC))
     1.OR.CONVAL.GT.AMAX1(A(II,JJ),A(II+IINC,JJ+JINC)))
     2GO TO 40
      IF (ILOG.LT.0) GO TO 30
      CONDEP=((CONVAL-A(II,JJ))/(A(II+IINC,JJ+JINC)-A(II,JJ)))
     1+FLOAT(II*IINC+JJ*JINC)
      RETURN
   30 CONTINUE
      CONLOG=ALOG10(CONVAL).
      CONDEP=((CONLOG-DLOG10(A(II,JJ)))/(DLOG10(A(II+IINC,JJ+JINC))-
     1DLOG10(A(II,JJ))))+FLOAT(II*IINC+JJ*JINC)
      RETURN
   40 CONTINUE
   45 CONTINUE
      RETURN
      END
```

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MICRON*SnS2(1).MAIN

```
C••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
C••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
C••                                                                    ••
C••                          PROCSIM  II                               ••
C••                                                                    ••
C••   SOLUTION OF DIFFUSION PROBLEM FOR SILICON ON SAPPHIRE            ••
C••            ••• NORMALIZED SOLUTION •••                             ••
C••                                                                    ••
C••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
C••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
C••                                                                    ••
C••           DATA IS READ FROM DECK IN FOLLOWING SEQUENCE:            ••
C••                                                                    ••
C••   FIRST CARD:                                                      ••
C••   LIST - # OF TIME STEPS TO BE SKIPPED WHILE PRINTING              ••
C••   IFILE - PUT 1 TO WRITE ON FILE AND ALSO TO LOCATE                ••
C••           CONTOUR POSITION,CONTOUR FRONT MOVEMENT DATA IS          ••
C••           WRITTEN ON UNIT 9 AND CONCENTRATION PROFILE IS           ••
C••           WRITTEN ON UNIT 11.                                      ••
C••   LFILE - # OF TIME STEPS TO BE SKIPPED WHILE WRITING ON FILE      ••
C••   IPLOT - PUT 1 TO PLOT PROFILE IN PRINT OUT                       ••
C••   IREAD - PUT 1 TO READ DATA FROM FILE                             ••
C••         - PUT 2 TO READ ION IMPLANT DATA AND TO                    ••
C••           DO REDISTRIBUTION.                                       ••
C••   JSTEP - # OF DATA STEPS TO BE READ FROM FILE IF IREAD = 1        ••
C••   IMAX1,JMAX1 - # OF GRID POINTS IN X AND Y DIRECTIONS             ••
C••                RESPECTIVELY.CHECK DIMENSION BEFORE CHANGING        ••
C••           FORMAT FIELD - 8I10                                      ••
C••                                                                    ••
C••   SECOND CARD:                                                     ••
C••   JSTP - PUT 0 IF CONST. SOURCE DIFF. IS DESIRED.                  ••
C••        - PUT 1 IF REDISTRIBUTION IS DESIRED.                       ••
C••        - PUT> 1 IF TWO-STEP DIFF. IS DESIRED                       ••
C••   ORINT - PUT 1 FOR 100 CRYSTAL ORIENTATION                        ••
C••         - PUT 2 FOR 110 CRYSTAL ORIENTATION                        ••
C••         - PUT 3 FOR 111 CRYSTAL ORIENTATION                        ••
C••   AMBNT - PUT 1 FOR DRY OXYGEN                                     ••
C••         - PUT 2 FOR STEAM                                          ••
C••         - PUT 3 FOR NITROGEN                                       ••
C••           FIELD 3I10                                               ••
C••                                                                    ••
C••   THIRD CARD:                                                      ••
C••   CSUB - SUBSTRATE DOPING/1.E15                                    ••
C••   CS - SURFACE CONCENTRATION/1.E18                                 ••
C••   TEMP - TEMPERATURE IN DEG. CENT.                                 ••
C••   TMAX - NORMALIZATION TIME IN SECOND                              ••
C••          THIS HAS NO EFFECT IF LAMDA IS SPECIFIED AS DATA          ••
C••   XDIST, YDIST - WIDTH AND THICKNESS(IN MICRON) OF THE TWO         ••
C••                  DIMENSIONAL REGION IN QUESTION                    ••
C••   OXTHIC - WIDTH(IN MICRON) OF THE OXIDE IN THE REGION             ••
C••   DELT - NORMALIZED TIME STEP                                      ••
C••           FORMAT FIELD - 8F10.3                                    ••
C••                                                                    ••
C••   FORTH CARD:                                                      ••
C••   IMTYPE - SPECIFY TYPE OF IMPURITY BY PUTTING N OR P              ••
C••            NO SPEC. IS NECESSARY IF IT IS BORON                    ••
C••   IMPUTY - PUT BORON,ARSENIC, PHOSPHOROUS OR ANY                   ••
C••            OTHER NAME.                                             ••
C••   EA - ACTIVATION ENERGY OF THE DIFFUSION                          ••
C••        IF BLANK AND BORON DIFF., DATA IS SUPPLIED INTERNALLY       ••
C••   DI - DIFFUSIVITY CONST. OF THE IMPURITY .                        ••
C••        IF BLANK AND BORON DIFF., DATA IS SUPPLIED INTERNALLY       ••
C••           FIELD A4,4A4,2F10.3                                      ••
C••                                                                    ••
C••   FIFTH CARD:                                                      ••
C••   ID - IDENTIFICATION COMMENT TO BE PRINTED ON TOP OF              ••
C••        PROFILE PRINT OUT                                           ••
C••   ITEST - PUT 0 TO READ LAMDA FROM DATA DECK                       ••
C••   CSTOP - CONCENTRATION/1.E15 AT WHICH SIMULATION STOPS            ••
C••           WHEN THE LEFT END CORNER OF SILICON AND SAPPHIRE         ••
C••           INTERFACE REACHES THIS VALUE(DURING PREDEP)              ••
C••           FORMAT FIELD - 15A4,I5,F15.9                             ••
C••                                                                    ••
C••   SIXTH CARD(USE IF JSTP>1):                                       ••
C••   RDTEMP - REDISTRIBUTION TEMPERATURE                              ••
C••   RDTMAX - REDISTRIBUTION NORM. TIME                               ••
C••            REDISTRIBUTION FINAL TIME IS 1.                         ••
C••   RDDLT - REDISTRIBUTION NORM. TIME STEP.                          ••
C••   XOA - REDISTRIBUTION INITIAL OXIDE THICKNESS IN CM               ••
```

```
C**              WHERE SURF. CONC. WAS CS                                    **
C**     XOB - REDISTRIBUTION INITIAL OXIDE THICKNESS IN CM                   **
C**              WHERE SURF. HAS THE THICK OXIDE                             **
C**     CM -   SEGREGATION COEFFICINT, GENERATED INTERNALLY IF               **
C**           IMPURITY IS BORON AND NO VALUE IS GIVEN                        **
C**     FIELD 6F10.3                                                         **
C**                                                                          **
C**     SEVENTH  CARD(USE WHEN ITEST=0):                                     **
C**     LAMDA - LAMDA**2/1.E-3                                               **
C**             FORMAT FIELD - F10.3                                         **
C**                                                                          **
C**     EIGHTH CARD(USE IF IREAD=2):                                         **
C**     ION IMPLANTATION DATA                                                **
C**     CMAX - MAX. CONCENTRATION                                            **
C**     RP - RANGE OF DISTRIBUTION, MEAN VALUE (IN MICRON )                  **
C**     DRP - STRAGGLE, STANDARD DEVIATION, (IN MICRON )                     **
C**     VOLT - IMPLANTATION ENERGY LEVEL IN KEV                              **
C**             FIELD 3E15.6,F10.5                                           **
C**                                                                          **
C*****************************************************************************
C
        IMPLICIT DOUBLE PRECISION (A-H,O-Z)
        INTEGER ORINT,AMBNT
        DOUBLE PRECISION KB,NI,LAMDA
        COMMON /TRI/ A(64),B(64),D(64),E(64),V(64)
        COMMON /CON/ CB1(64,64)
        DIMENSION X(64), Y(64), CB(64,64), CB2(64,64), G(64,64), ID(15)
        DIMENSION IMTYPE(1), IMPUTY(4), IBRON(4)
        DIMENSION XOLAST(64), XO(64), DRRXO(64),YP(64)
        DIMENSION  IMAT(2),IORNT(1),IDOX(2),INIT(2),ISTM(1)
C
C      DEFINE COMPUTING FUNCTIONS
C
        RHS(Q,G1,G3,C10,C00,C20)=C00+Q*(G1*C20+G3*C10)
        RATIO(C,CSUB,NI)=(C-CSUB)/(2.*NI)
        ROOT(RATIO)=DSQRT((RATIO**2)+1.0)
        FU(RATIO,ROOT)=((RATIO+ROOT)**2)/ROOT
        CALL ERTRAN (9,IDATE,ITIME)
C
C      READ SIMULATION INITIAL DATA
C
        READ 360, LIST,IFILE,LFILE,IPLOT,IREAD,JSTEP,IMAX1,JMAX1
        READ 360, JSTP,ORINT,AMBNT
        IF(IREAD.EQ.2) JSTP=1
        READ 370, CSUB,CS,TEMP,TMAX,XDIST,YDIST,OXTHIC,DELT
        READ 320, IMTYPE,IMPUTY,EA,DI
        READ 380, ID,ITEST,CSTOP
        IF (JSTP.GT.0) READ (5,370,ERR=310) RDTEMP,RDTMAX,RDDLT,XOA,XOB,CM
        IF (ITEST.EQ.0) READ (5,370,ERR=310) LAMDA
C
C      DEFINE DATA:
C
C      KB - BOLTZMANN'S CONSTANT
C      JLIM - # OF ALLOWABLE ITERATIONS
C      DVLIM - ALLOWABLE ERROR IN CONVERGENCE
C      TIMAX - NORMALIZED TIME AT WHICH SIMULATION STOPS
C      EAB AND DIB - BORON DIFFUSIVITY DATA
C
        DATA EAB,DIB /3.59D0,1.17D0/
        DATA IBRON /4HBORO,4HN   ,4H    ,4H    /
        DATA NYP,IPT /1HN,1HP/
        DATA KB /8.616D-5/
        DATA JLIM,DVLIM /60,1.D-8/ ,TIMAX /1.D0/
        DATA IDOX/6HDRY OX,6HYGEN  /
        DATA INIT/6HNITROG,6HEN    /
        DATA ISTM/6HSTEAM /
C
        IF (IMPUTY.EQ.IBRON) IMTYPE=IPT
        IER=0
        IF (JSTP.EQ.1.AND.IREAD.EQ.0) IER=1
        IF (IMPUTY.NE.IBRON.AND.EA.EQ.0.D0) IER=1
        IF (IMPUTY.NE.IBRON.AND.DI.EQ.0.D0) IER=1
        IF (IER.EQ.1) PRINT 460
        IF (IER.EQ.1) GO TO 310
        IF (IMTYPE.EQ.IPT) ITYPE=0
        IF (IMTYPE.EQ.NYP) ITYPE=1
        IF (IMPUTY.EQ.IBRON.AND.EA.EQ.0.D0) EA=EAB
        IF (IMPUTY.EQ.IBRON.AND.DI.EQ.0.D0) DI=DIB
        PRINT 410, ID
        PRINT 330, IMPUTY,IMTYPE
```

```
      NAMELIST /PUT/ LIST,IFILE,LFILE,IPLOT,IREAD,JSTEP,IMAX1,JMAX1,JSTP
     1,ORINT,AMBNT,CSUB,CS,TEMP,TMAX,XDIST,YDIST,OXTHIC,DELT,EA,DI,ITEST
     2,CSTOP,LAMDA,RDTEMP,RDTMAX,RDDLT,XOA,XOB,CM,JLIM,DVLIM,TIMAX
      WRITE (6,PUT)
C
C     REFORMATION OF COMPUTING, GEOMETRIC AND PHYSICAL PARAMETERS
C
      IF(JSTP.EQ.0.OR.JSTP.GT.1) ICOND=1
      IF(ICOND.EQ.1) AMBNT=3
      IF(AMBNT.NE.3) XDIST=XDIST*1.D-4
      IF(AMBNT.NE.3) YDIST=YDIST*1.D-4
      IF(AMBNT.NE.3) OXTHIC=OXTHIC*1.D-4
      JMAX=JMAX1-1
      KOTI=0
      IMAX=IMAX1-1
      IMAX2=IMAX1+1
      IF(IMAX1.GT.3) GO TO 5
      DELX=6.D0
      IF(AMBNT.NE.3) DELX=6.D-4
      GO TO 6
    5 DELX=XDIST/FLOAT(IMAX2-3)
    6 DELY=YDIST/FLOAT(JMAX)
      CSUB=CSUB*1.D15
      CSTOP=CSTOP*1.D15
      LAMDA=LAMDA*1.D-3
      CS=CS*1.D18
      T=TEMP+273.
      WINDO=(XDIST-OXTHIC)+1.D-5
      GM=CM
      CM=1.0
      TMX=TMAX
      IF(AMBNT.EQ.1) IMAT(1)=IDOX(1)
      IF(AMBNT.EQ.1) IMAT(2)=IDOX(2)
      IF(AMBNT.EQ.2) IMAT=ISTM
      IF(AMBNT.EQ.3) IMAT(1)=INIT(1)
      IF(AMBNT.EQ.3) IMAT(2)=INIT(2)
      IF(ORINT.EQ.1) IORNT='100'
      IF(ORINT.EQ.2) IORNT='110'
      IF(ORINT.EQ.3) IORNT='111'
C
C     CALCULATE DISTANCE X AND Y
C
      DO 10 I=2,IMAX1
        X(I)=(I-2)*DELX
   10   IF (X(I).LE.WINDO) K=I
      DO 20 J=1,JMAX1
   20   Y(J)=(J-1)*DELY
      DO 30 I=2,IMAX1
   30   XOLAST(I)=XOA
      DO 31 J=JMAX1,1,-1
   31 YP(J)=(JMAX1-J)*(1./FLOAT(JMAX))
C
C     SPECIFY PREDEP CONDITIONS
C
      DO 40 I=1,IMAX2
        DO 40 J=1,JMAX1
          CB(I,J)=0.0
          CB1(I,J)=0.0
   40     CB2(I,J)=0.0
      DO 50 I=2,K
        CB(I,JMAX1)=CS
        CB1(I,JMAX1)=CS
   50   CB2(I,JMAX1)=CS
      TIME=0.0
      LM=0
C
C     SPECIFY INITIAL PROFILE
C
      IF(IREAD.EQ.2) CALL SUBION(IMAX1,JMAX1,K,Y,YDIST,CSTOP)
      IF (IREAD.EQ.1) CALL XYZ (IMF1,JMF1,X,Y,LM,TIME,KA,DFA,TMP,TIMX,JS
     1TEP,XOLAST,YDIST,AMBNT)
      IF(IREAD.EQ.1) TIMAX=TIME+1.0
      STIME=TIME
      IF (JSTP.EQ.1) ICOND=2
C
C     READ CONTOUR FRONT MOVEMENT FROM DATA FILE IF IREAD = 1
C
      IF (IREAD.EQ.1) CALL FRONT (IM1,JM1,LA,KC,TMPR,DFB,DLT,LM,1,KOTI,X
     1DIST)
      IF (IREAD.EQ.1) PRINT 430, LM,TIME,TMP,DFA,TIMX,IMF1,JMF1,KA
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      IF (IREAD.EQ.1) PRINT 440, TMF,,DFB,LA,IM1,JM1
      IF (IREAD.NE.1) GO TO 60
      IF (IMF1.NE.IMAX1.OR.JMF1.NE.JMAX1.OR.KA.NE.K) IER=1
      IF (IM1.NE.IMAX1.OR.JM1.NE.JMAX1.OR.KC.NE.K.OR.LA.NE.LM) IER=1
      IF (IER.EQ.1) PRINT 450
      IF (IER.EQ.1) GO TO 310
C
C     START SIMULATION STEP
C
   60 IF (ICOND.EQ.1) GO TO 70
      KOTI=0
      TEMP=RDTEMP
      T=TEMP+273.
      DELT=RDDLT
      TMAX=RDTMAX
      IF(AMBNT.NE.3) DELT=DELT*TMAX
      IF(AMBNT.NE.3) TIMAX=TMAX
      TIME=0.
   70 CONTINUE
C
C     CALCULATE NI
C
      TIMAX=TIMAX-DELT
      CALL PARAM (NI,T)
      DF=DI*DEXP(-EA/(KB*T))
      IF (ITEST.NE.0) DFI=DF*TMAX/((YDIST*1.D-4)**2)
      IF(AMBNT.NE.3) DFI=DF
      IF (ITEST.EQ.0) DFI=LAMDA
      IF (ICOND.EQ.1) PRINT 340
      IF (ICOND.EQ.2) PRINT 350
      PRINT 390, NI,DF
      PRINT 420, IMPUTY,TEMP,DFI,TMAX
C
      P=(DFI*DELT)/(DELY**2)
      Q=(DFI*DELT)/(DELX**2)
C
C     PRINT INITIAL PROFILE
C
      CALL OUTPUT (X,Y,IMAX1,JMAX1,K,LM,JJ,TIME,YDIST,ID,ITIME,XOLAST,
     * PTIME,DTIME,AMBNT)
      IF (IREAD.EQ.2.AND.IFILE.EQ.1) CALL ABC (IMAX1,JMAX1,X,Y,LM,TIME,K
     1,DFI,TEMP,TMAX,KOTI,XOLAST,YDIST,AMBNT)
      AM=1.0
      CC=1.0
      BB=1.0
      IF (ICOND.NE.1) CALL OXDATA (AMBNT,ORINT,T,BB,
     1CC,AM,KB)
      IF(ICOND.EQ.2.AND.GM.EQ.0.) CM =AM
      IF(ICOND.EQ.2.AND.GM.NE.0.) CM =GM
      IF(ICOND.EQ.2)    PRINT 421, IMBT,IORNT,BB,CC,CM
C
C     START TIME STEP LOOP
C
   80 LM=LM+1
C
C     STORE N TH. RESULT FOR R.H.S..WILL NOT BE CHANGED DURING ITER.
C
      TIME=TIME+DELT
      IF(ICOND.EQ.1) STIME=TIME
      PTIME=TMX*STIME
      IF(ICOND.EQ.2) PTIME=TMX
      DTIME=RDTMAX*(TIME-STIME)
      IF(AMBNT.NE.3) DTIME=TIME
      DO 90 I=1,IMAX2
        DO 90 J=1,JMAX1
   90     CB2(I,J)=CB1(I,J)
      IF (ICOND.EQ.1) GO TO 110
C
C     CALCULATE OXIDE THICKNESS
C
      IF(AMBNT.NE.3) GO TO 95
      DO 94 I=2,IMAX1
   94   XO(I)=XOLAST(I)
      GO TO 110
   95 PS=BB*DELT
      QS=BB/CC
      DO 100 I=2,IMAX1
        XO(I)=XOLAST(I)+PS/(2.*XOLAST(I)+QS)
  100   DRBXO(I)=(XO(I)-XOLAST(I))/DELT
      XO(1)=XO(2)
```

```
          IF((YDIST-0.45*XO(1)).LT.0.1D-4) GO TO 310
      110 CONTINUE
          DELY=(1./FLOAT(JMAX))*(YDIST-0.45*XOLAST(2))
          IF(AMBNT.NE.3) P=(DFI*DELT)/(DELY**2)
          JJ=0
          JM=0
C
C         START ITERATION LOOP
C
      120 JJ=JJ+1
          IF (JJ.GT.JLIM) PRINT 400, CTER
          IF (JJ.GT.JLIM) GO TO 290
C
C         TRANSFER SOLN. VECTOR FROM LAST ITERA. FOR CAL. OF G
C
          DO 130 I=1,IMAX2
            DO 130 J=1,JMAX1
      130     CB(I,J)=CB1(I,J)
C
C         CAL.G
C
          DO 140 I=1,IMAX2
            DO 140 J=1,JMAX1
              RA=RATIO(CB(I,J),CSUB,NI)
              RO=ROOT(RA)
      140     G(I,J)=FU(RA,RO)
C
C         SOLVE SYSTEM IN Y DIRECTION
C
          DO 220 I=2,IMAX1
C
C         CALCULATE THE COEFF. IN Y DIRECTION
C
          SR=0.
            DO 150 J=2,JMAX
              G1=(G(I,J)+G(I+1,J))/2.0
              G2=(G(I,J)+G(I,J+1))/2.0
              G3=(G(I,J)+G(I-1,J))/2.0
              G4=(G(I,J)+G(I,J-1))/2.0
          IF(AMBNT.EQ.3) GO TO 151
          SR=0.45*DRRXO(I)*(YP(J)-1.0)*DELT/DELY
      151 CONTINUE
              A(J)=-P*G4
              B(J)=1.+Q*(G1+G3)+P*(G2+G4)+SR
              D(J)=-P*G2-SR
      150     E(J)=RHS(Q,G1,G3,CB(I-1,J),CB2(I,J),CB(I+1,J))
C
C         PUT BOUNDARY CONDITION ON Y AXIS
C
            B(2)=A(2)+B(2)
            A(2)=0.0
            IF (ICOND.NE.1) GO TO 170
            IF (I.GT.K) GO TO 160
            E(JMAX)=E(JMAX)-D(JMAX)*CS
            D(JMAX)=0.0
            GO TO 180
      160   CONTINUE
            B(JMAX)=B(JMAX)+D(JMAX)
            D(JMAX)=0.0
            GO TO 180
      170   IF (AMBNT.EQ.3) DRRXO(I)=0.
            HA=-DELY*(1./CM-0.45)*DRRXO(I)
         HB=2.*DFI
            HK1=HA/(HB*G(I,JMAX1))
            HK2=HA/(HB*G(I,JMAX))
            B(JMAX)=B(JMAX)+((1.+HK2)/(1.-HK1))*D(JMAX)
            D(JMAX)=0.
      180   CONTINUE
C
            CALL TRIDAG (2,JMAX)
C
C         CONVERT MATRIX SOLUTION
C
            DO 190 J=2,JMAX
              CB1(I,J)=V(J)
      190 CONTINUE
C
C         PUT BOUNDARY VALUES IN Y
C
              CB1(I,1)=CB1(I,2)
```

```
          IF (ICOND.NE.1) GO TO 210
          IF (I.GT.K) GO TO 200
          CRI(I,JMAX1)=CS
          GO TO 220
  200     CBI(I,JMAX1)=CRI(I,JMAX)
          GO TO 220
  210     CONTINUE
          CBI(I,JMAX1)=((4.+HK2)/(1.+HK1))*CBI(I,JMAX)
        IF(CRI(I,JMAX1).LT.1.D-300) CRI(I,JMAX1)=1.D-300
  220     CONTINUE
C
C     PUT BOUNDARY VALUES IN AXIS X(PERIODIC BOUNDARY)
C
        DO 230 J=1,JMAX1
          CRI(1,J)=CBI(3,J)
  230     CBI(IMAX2,J)=CRI(IMAX,J)
C
C     CHECK FOR CONVERGENCE
C
        IF (JJ.EQ.1) GO TO 120
        ICK=0
        DO 240 I=1,IMAX1
          DO 240 J=1,JMAX
            IF (CBI(I,J).LE.0.D) GO TO 240
            CTEST=DABS((CRI(I,J)-CR(I,J))/CBI(I,J))
            IF (CTEST.LE.DVLIM) GO TO 240
            CTER=DMAX1(CTEST,CTER)
            ICK=1
  240       CONTINUE
        IF (ICK.NE.0) GO TO 120
        JM=JM+1
        DO 241 I=1,IMAX1
        DO 241 J=1,JMAX1
  241   IF(CRI(I,J).LT.0.D0)    CBI(I,J)=CBI(I,J)
        IF(JM.EQ.1) GO TO 120
C
C     PRINT RESULTS
C
        IS=LM/LIST*LIST-LM
        IF (IS.EQ.0) GO TO 250
        IF (TIME.GE.TIMAX.AND.CS.NE.0.D) GO TO 250
        IF(CRI(2,1).GE.CSTOP.AND.ICOND.EQ.1) GO TO 250
        IF(CBI(2,1).GE.CSTOP.AND.CS.EQ.0.D.AND.JSTP.EQ.1) GO TO 250
        GO TO 260
 250    CALL OUTPUT (X,Y,IMAX1,JMAX1,K,LM,JJ,TIME,YDIST,ID,ITIME,XO,
       * PTIME,DTIME,AMBNT)
        CALL SHREJN (CSUR,YDIST,JMAX1,Y,TIME,DELT,DELY,TEMP,TMAX,IFILE,ITY
       1PE,AMANT,XO(2))
        IF (IPLOT.NE.1) GO TO 260
        CALL PLOT (CS,IMAX1,JMAX1,K)
C
C     STORE TRANSIENT DATA
C
  260   IF (IFILE.EQ.0) GO TO 270
        IT=LM/LFILE*LFILE-LM
        IF(IT.EQ.0) GO TO 265
        IF(TIME.GE.TIMAX) GO TO 265
        IF(CBI(2,1).GE.CSTOP.AND.ICOND.EQ.1) GO TO 265
        GO TO 266
  265   CALL ABC(IMAX1,JMAX1,X,Y,LM,TIME,
       1K,DFI,TEMP,TMAX,KOTI,XO,YDIST,AMANT)
C
C
C     LOCATE CONTOUR POSITION AND STORE DATA
C
  266   CONTINUE
        CALL FRONT (IMAX1,JMAX1,LM,K,TEMP,DFI,DELT,JSTEP,D,KOTI,XDIST)
  270   CONTINUE
C
C     GO TO NEXT TIME STEP
C
        IF (CRI(2,1).GE.CSTOP.AND.ICOND.EQ.1) GO TO 290
        IF (TIME.GE.TIMAX) GO TO 290
        XO(1)=XO(2)
        DO 280 I=2,IMAX1
  280     XOLAST(I)=XO(I)
        GO TO 80
  290   IF (JSTP.GT.1.AND.ICOND.EQ.1) GO TO 300
        GO TO 310
  300   TIMAX=TIME+1.
```

```
      IF(AMBNT.NE.3) TIMAX=TIME+RDTMAX
      ICOND=2
      GO TO 60
  310 IF(LM.EQ.0) PRINT 450
      STOP
C
  320 FORMAT (A4,4A4,2F10.3)
  330 FORMAT (1H0,20X,'IMPURITY = ',4A4,2X,'IMPURITY TYPE = ',A4)
  340 FORMAT (1H0,20X,'*** PREDEPOSITION CYCLE ***')
  350 FORMAT (1H1,20X,'*** REDISTRIBUTION CYCLE ***')
  360 FORMAT (8I10)
  370 FORMAT (8E10.5)
  380 FORMAT (15A4,I5,F15.9)
  390 FORMAT (//,1H0,10X,'NI = ',D10.3,5X,'DFI = ',D10.3//)
  400 FORMAT (//,1H0,10X,'ITERATION DID NOT CONVERGE, ERROR = ',D10.3)
  410 FORMAT (1H1,10X,'***  SOLUTION OF DIFFUSION PROBLEM FOR SILICON,
     1 ON SAPPHIRE  ***'//1H0,31X,'NORMALIZED SOLUTION'//1H ,10X,15A4//1
     2H0,10X,'FOLLOWINGS ARE THE DATA VALUE')
  420 FORMAT (//,1H0,10X,'NI = INTRINSIC CARRIER CONC.'//1H ,10X,'DFI =
     1  INTRINSIC DIFFUSIVITY OF',1X,4A4,2X,'AT',2X,F10.3,2X,'DEG. CENT.
     2'//1H ,10X,'LAMDA = LAMDA**2 = DFI*TMAX/(YMAX*1.E-4**2)'//1H ,10X,
     3'LAMDA = ',D10.3,5X,'FOR NORMALIZATION TIME = ',E12.6,2X,'SEC.')
  421 FORMAT(//,1H0,10X,'AMBIENT = ',2A6/1H0,5X,'CRYSTAL ORIENTATION = '
     *A4//1H0,5X,'OXIDATION PARAMETERS:',5X,2X,'B = ',
     *E10.3,2X,'C = ',F10.3,/
     *1H0,5X,'SEGRAGATION COEFF. = ',E10.3)
  430 FORMAT (1H0,10X,'*** INITIAL PROFILE AT TIME STEP = ',I5,2X,'TIME
     1= ',D10.3,2X,'HAS BEEN READ IN FROM DATA FILE 11 ***'/1H0,15X,'FOL
     2LOWING DATA ARE PROVIDED:'//1H ,15X,'TEMP = ',D10.3,2X,'LAMDA**2 =
     3 ',D10.3,2X/1H ,15X,'NORM. TIME = ',D10.3,2X,'IMAXI = ',I10,2X,'JM
     4AXI = ',I10,2X,'OXIDE GRID = ',I6)
  440 FORMAT (1H0,10X,'*** FOLLOWING DATA ARE OBTAINED FROM THE DATA
     1  FILE 9 ***'//1H ,10X,'TEMP = ',F10.3/1H ,10X,'LAMDA**2 = ',D10.
     23/1H ,10X,'TIME STEP = ',I10/1H ,10X,'IMAXI = ',I5/1H ,10X,'JMAXI
     3 = ',I5)
  450 FORMAT (1H0,10X,'***DATA INPUT ERROR ***'/1H0,8X,'RUNSTREAM TERMIN
     1ATED')
C
      END

@PRT 5052.SHREJN..MAIN-PLOT
```

```
MICRON*SOS2(1).SHREJN
          SUBROUTINE SHREJN(CSUB,YDIST,JMAX1,X,TIME,DELT,DELY,
         *  TEMP,TMAX,IFILE,ITYPE,IAMBNT,XO)
C*************************************************************************
C               SUBROUTINE FOR CALCULATING SHEET RESISTANCE AND JUNCTION
C*************************************************************************
          IMPLICIT DOUBLE PRECISION(A-H,O-Z)
          COMMON /CON/C(64,64)
          DIMENSION CNET(64),CBI(64),X(1),Y(64)
          DEL=YDIST/FLOAT(JMAX1-1)
          IF(IAMBNT.NE.3) DEL=DEL/YDIST
          YWJ=0.0
          YWJ1=0.0
          DO 6 I=1,JMAX1
          IJ=JMAX1-I+1
          Y(I)=YDIST-X(IJ)
        6 IF(IAMBNT.NE.3) Y(I)=(I-1)*(1./FLOAT(JMAX1-1))
          JN1=1
          ICK=0
          DO 5 J=JMAX1,1,-1
          I=JMAX1+1-J
          CBI(I)=C(2,J)
          IF(CBI(I).LT.CSUB.AND.ICK.EQ.0) JN1=I
          IF(CBI(I).GT.CSUB) ICK=1
          IF(CBI(I).GT.CSUB) JN=I
        5 CNET(I)=CBI(I)-CSUB
          IF(JN1.EQ.1.OR.JN.EQ.(JMAX1-1).OR.JN.EQ.JMAX1) GO TO 7
          YWJ=(YDIST/(JMAX1-1))*(CBI(JN)-CSUB)/(CBI(JN)-CBI(JN+1))
          IF(IAMBNT.NE.3) YWJ=YWJ/YDIST
          YWJ1=DEL*(CSUB-CBI(JN1))/(CBI(JN1+1)-CBI(JN1))
        7 K=0
          SIGMA=0.0D0
          Q=0.D0
C
C               START INTEGRATION
C
        1 K=K+1
          IF(K.GE.JMAX1) GO TO 2
          Q=Q+(CBI(K+1)+CBI(K))*DEL/2.D0
          IF(K.LE.JN1.OR.K.GE.JN) GO TO 1
          SIG1=G(DABS(CNET(K)),ITYPE)
          SIG2=G(DABS(CNET(K+1)),ITYPE)
          SIGMA=SIGMA+(Y(K+1)-Y(K))*((SIG2+SIG1)/2.0D0)
          GO TO 1
        2 CONTINUE
          IF(JN.EQ.JMAX1) YWJ=0.0
          IF(JN1.EQ.1.AND.CBI(JN1).GT.CSUB) YWJ1=0.0
          SIGA=G(DABS(CNET(JN+1)),ITYPE)
          SIGB=G(DABS(CNET(JN1)),ITYPE)
          SIGC=G(DABS(CNET(JN1+1)),ITYPE)
          YJUNC=Y(JN)+YWJ
          SIGIN=G(DABS(CNET(JN)),ITYPE)
          SIGWJ=0.5*(YWJ*(SIGIN+SIGA)+(DEL-YWJ1)*(SIGB+SIGC))
          YWJ1=Y(JN1)+YWJ1
          SIGMA=SIGMA+SIGWJ
          RS=1.0D0/SIGMA
          WRITE(6,203)  YWJ1,YJUNC,,RS,Q
      203 FORMAT(/,5X,'JUNCTION IS AT ',2D15.9,' CM',5X,/,
         *5X,'SHEET RESISTANCE = ',D15.9,3X,
         * /3X,'INTEGRATED IMPURITY=',D15.9)
          WRITE(6,201) JN1,JN
      201 FORMAT('0',5X,'JN=',2I5/)
          AFAC=1.0
          IF(IAMBNT.NE.3) AFAC=(YDIST-0.45*XO)/1.D-4
          YJUNC=YJUNC*AFAC
          RS=RS/(AFAC*1.D-4)
          Q=Q*AFAC*1.D-4
          IF(IFILE.EQ.1) CALL SHFILE(TIME,DELT,DELY,TEMP,
         *  TMAX,RS,YWJ1,YJUNC,Q,JMAX1,YDIST,XO,IAMBNT)
          RETURN
          END
```

```
MICRON*SnS2(1).MAIN-PLOT
      C     ** ISOCONCENTRATION PLOT PROGRAM **
      C
      C              READ IN FROM DATA DECK
      C       FIRST CARD: LL - # OF TIME STEPS TO BE
      C                       READ IN FROM DATA FILE. FIELD I3.
      C       SECOND CARD: IIT - TIME STEPS TO BVE SKIPPED WHILE
      C                          PLOTTING PROFILE. DEFAULT PLOT AT
      C                          TIME STEPS 1 AND AT LL. FIELD I3.
      C
            DIMENSION CB(64,64),XC(64),YC(64),XO(64)
            DATA XMAX,YMAX/8.0,4.0/OX/3.6/
            DATA IDOL,IBLNK/1H$,1H /
            DATA HGT/0.0875/
            READ (5,3) LL
            READ(5,3) IIT
      3     FORMAT (I3)
      C*    * READ DATA FILE 11
            DO 100 L=1,LL
            READ(7,4) MARK
          4 FORMAT(1H0,A6)
            IF(MARK.NE.IDOL) GO TO 5
            READ(7,1) DFI,TMAX,TEMP,YDIST
            READ(7,2) K,IMAX1,JMAX1,IAMBNT
            IK=IMAX1
            JK=JMAX1
      1     FORMAT(1H ,5E15.9)
      2     FORMAT(1H ,8I10)
            READ(7,1) (XC(I),I=2,IK)
            READ(7,1) (YC(I),I=1,JK)
            READ(7,4) MARK
          5 CONTINUE
            READ(7,2) LM
            READ(7,1) TIME
            DO 99 J=JK,1,-1
            READ(7,1) (CB(I,J),I=2,IK)
            DO 60 I=2,IK
         60 IF(CB(I,J).LE.1.E-30) CB(I,J)=1.E-30
      99    CONTINUE
            READ(7,1) (XO(I),I=2,IK)
            IS=L/IIT*IIT-L
            IF(IS.EQ.0) GO TO 11
            IF(L.EQ.1.OR.L.EQ.LL) GO TO 11
            GO TO 100
         11 CONTINUE
      C*    * INITIALIZE PLOT.
            CALL PLOTS(10.0,10.0)
      C*    * RESET PEN TO ORIGIN
            CALL PLOT(1.0,2.0,-3)
      C*    * DRAW RORDER
            CALL PLOT(0.0,YMAX,2,-1)
            CALL PLOT(XMAX,YMAX,2,-1)
            CALL PLOT(XMAX,0.0,2,-1)
            CALL PLOT(0.0,0.0,2,-1)
      C*    * DRAW OXIDE MASK
            XP=(XC(IK)-2.)
            IF(IAMBNT.NE.3) XP=(XC(IK)-2.E-4)/1.E-4
            OX=(8./XP)*XC(K)
            CALL PLOT(OX,YMAX,3)
            CALL PLOT(OX,YMAX+0.2,2,-1)
            CALL PLOT(XMAX,YMAX+0.2,2,-1)
            CALL PLOT(XMAX,YMAX,2,-1)
            X=XMAX
            PAT=8.-OX
            INC=INT(PAT/0.2)
            DO 10 I=1,INC
            X=X-0.2
            CALL PLOT(X,YMAX+0.2,2,-1)
            CALL PLOT(X,YMAX,3)
         10 CONTINUE
            CALL PLOT(0.0,0.0,3)
      C*    * HORIZONTAL GRID LINES
            DO 20 I=1,9
            Y=0.4*FLOAT(I)
            LNWT=+3
            IF (I.EQ.5) LNWT=+1
            CALL PLOT(0.0,Y,3)
            CALL PLOT(XMAX,Y,2,LNWT)
         20 CONTINUE
      C*    * VERTICAL GRID LINES
```

```
            DO 30 I=1,19
            X=0.4*FLOAT(I)
            LNWT=+3
            IF (MOD(I,5).EQ.0) LNWT=+1
            CALL PLOT(X,0.0,3)
            CALL PLOT(X,YMAX,2,LNWT)
         30 CONTINUE
C*          * HORIZONTAL AXIS NUMBERS
            DEX=XP/20.
            IE=21
            IG=1
            IF(DEX.LT.0.1) IE=11
            IF(DEX.LT.0.1) IG=2
            IF(DEX.LT.0.01) DEX=XP/10.
            IF(IAMBNT.EQ.3) GO TO 31
            IG=1
            DEX=XP/20.
            IE=21
         31 CONTINUE
            DO 40 I=1,IE
            VAL=DEX*FLOAT(I-1)
            X=0.4*FLOAT(I-1)-1.5*HGT+0.04
            Y=-0.2
            CALL NUMBER(X,Y,HGT,VAL,0.0,16)
         40 CONTINUE
C*          * VERTICAL AXIS NUMBERS
            IF(IAMBNT.NE.3) YAK=YC(JK)/1.E-4
            DEY=YAK/10.
            DO 50 I=1,11
            VAL=DEY*FLOAT(I-1)
            X=-3.0*HGT-0.1
            Y=YMAX-0.4*FLOAT(I-1)-0.5*HGT
            CALL NUMBER(X,Y,HGT,VAL,0.0,1)
         50 CONTINUE
            CALL SYMBOL(4.2,5.7,0.1,'= 1.0E20',0.0,8)
            CALL SYMBOL(4.2,5.5,0.1,'= 1.0E19',0.0,8)
            CALL SYMBOL(4.2,5.3,0.1,'= 1.0E18',0.0,8)
            CALL SYMBOL(4.2,5.1,0.1,'= 1.0E17',0.0,8)
            CALL SYMBOL(4.2,4.9,0.1,'= 1.0E16',0.0,8)
            CALL SYMBOL(4.2,4.7,0.1,'= 1.0E15',0.0,8)
            CALL SYMBOL(4.0,5.7,0.1,0,0.0,-1)
            CALL SYMBOL(4.0,5.5,0.1,1,0.0,-1)
            CALL SYMBOL(4.0,5.3,0.1,2,0.0,-1)
            CALL SYMBOL(4.0,5.1,0.1,3,0.0,-1)
            CALL SYMBOL(4.0,4.9,0.1,4,0.0,-1)
            CALL SYMBOL(4.0,4.7,0.1,5,0.0,-1)
            CALL SYMBOL(0.0,5.4,0.2,'                   = ',0.0,14)
            CALL SYMBOL(0.,5.4,.2,41,0.,-1)
            CALL SYMBOL(999.,.5,.1,'2',0.,1)
            CALL NUMBER(2.6,5.4,0.2,DF1,0.,4)
            CALL SYMBOL(0.0,5.1,0.2,'TEMPERATURE = ',0.0,14)
            CALL NUMBER(2.6,5.1,0.2,TEMP,0.0,0)
            CALL SYMBOL(0.0,4.8,0.2,'TIME STEP   = ',0.0,14)
            TLM=LM
            CALL NUMBER(2.6,4.8,0.2,TLM,0.0,-1)
            CALL SYMBOL(0.0,4.5,0.2,'TIME        = ',0.0,14)
            CALL NUMBER(2.6,4.5,0.2,TIME,0.0,2)
            DO 200 II=1,6
            CONVAL=10.0**FLOAT(20-II+1)
            CALL PLTCON(CB,CONVAL,II,IK,JK)
    200     CONTINUE
            CALL PLOT(0.0,0.0,999)
    100     CONTINUE
            STOP
            END
```

DFIN