4. Main Menu and Key Functions

After leaving the title page, the monitor shows the pattern field, where any pattern file can be loaded, and on the right hand side the main menu or any submenu.

Fig. 4-1 shows a the pattern file "HEMT.GDB" (several layers are superimposed) and on the right hand side the main menu with commands leading to submenus. In addition there are functions for magnifying the pattern around the cursor position by zoom (commands "*" and "/") and a Help command (see section 4.7).

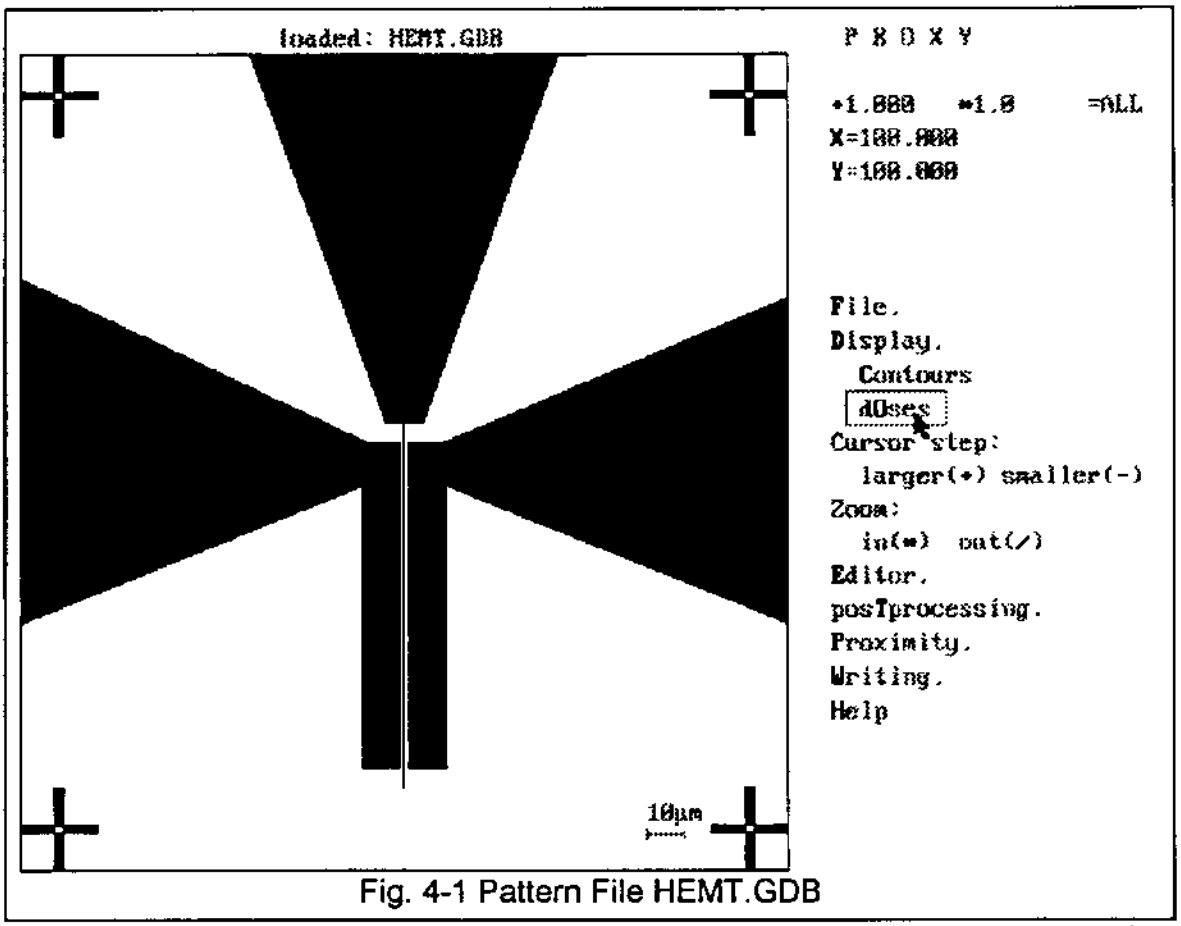

Fig. 4-1 Pattern File HEMT.GDB

The commands in all menus have either no, one or two points next to them. Commands without point work directly (e.g. Contours, doses). One point indicates that this command leads to a submenu with more commands (e.g. File., Display.). Two points indicate also direct commands, but these are attached with a special parameter submenu (e.g. Frame.., Shrink..). Each command contains a highlighted capital letter.

To carry out a function or to open a submenu follow one of the methods described below:

- Press the corresponding key on your keyboard for direct commands or for opening submenus.

> NOTE: Do not use the SHIFT key, otherwise the command will not operate. Make sure that the CAPS LOCK key on your keyboard is released.

- Move the mouse until a frame appears around the desired command or around the two points (for opening the attached parameter menu) and click the left mouse button or use the ENTER key.
- Use the arrow keys of your keyboard to move the cursor to the desired command. When a frame appears at the correct place use the ENTER key to confirm.

To leave a submenu use the Esc key or click the right mouse button.

To move the cursor between inside and outside the pattern field use **F2** or click the left mouse button while the cursor is at the border of the pattern field.

There are four different kinds of functions:

- functions which are carried out at once (e.g. "**H**elp", "**C**ontours"),
- functions which need confirmation (e.g. "**P**rint"),
- functions which need data input (e.g. "**S**ave"),
- functions which need an area selection (e.g. "**W**rite").

Data input is requested and displayed at top of the screen. Use the ENTER key to confirm or the Esc key to cancel data input.

Request of area selection is indicated at the bottom right hand side of the screen by "Select area ..". Move the cursor to one corner of the rectangular area you want to select and hit the space bar or click the left mouse button. A third dot appears next to the indication: "Select area ...". Move the cursor to the opposite corner of the wanted rectangular area and use the ENTER key or click the left mouse to confirm. Use the ENTER key twice in order to select the total field.

Besides the keys described by capitals of function names, which work only if the corresponding submenu is opened, there are several "hot keys" which can be activated at any time during PROXY-WRITER operation, even if other submenus are opened. These keys are marked by round brackets (e.g. (Alt+P) to make a hard copy or (Alt+X) to leave the program).

4.1 Cursor Position (X, Y)

In the PROXY design field a cross indicates the position of the design cursor. After program start this cursor is located in the center of the field. When the cursor is inside the design field its current X and Y coordinates are displayed (in µm) at the right

hand side, near the top of the screen, with a resolution of 1 nm. The default size of the design field is 20 µm x 20 µm where the center coordinates are X=10.000 and Y=10.000. The origin of this coordinate system is located in the bottom left hand corner of the design field. To move the design cursor follow one of the methods described below:

- Use the arrow keys of your keyboard (UP, DOWN, LEFT, RIGHT, HOME, END, PG.UP, PG.DOWN) for moving parallel or diagonal to the axes.
- If a mouse driver is installed move the mouse until the desired position is reached.
- Press the key "**X**" ("**Y**"). Enter the appropriate X value (Y value) and confirm by ENTER key.

4.2 Cursor Step Size (+, -)

At top of the screen beside the design field the cursor step size is displayed. The default value after program start is 1.000 µm. To change this value, use the "**+**" and "**-**" keys of your keyboard. The minimum cursor step is 1 nm.

The step size influences the cursor speed, when you move by mouse or by arrow keys, but the digital XY coordinate input of the appropriate cursor position is completely independent of the step size. That means, even if a step size of 20 µm is chosen, you may enter XY coordinates down to nm values.

4.3 Zoom (*, /)

Besides the cursor step size the current zoom value is displayed. The default value after program start is *1. To change the zoom, use the "*" and "/" keys on your keyboard. The minimum zoom value is 1, the maximum zoom depends on the zoom factor which can be changed in the adjustment menu of the "Display." function (see section 5.4).

The zoom function is useful to design small structures in a large field. Move the cursor to the point of interest and use the "*" key to decrease the displayed area around the cursor (increasing of magnification). After each magnification step, the cursor is located in the center of the magnified area. You may move the cursor to a new point of interest and carry out more magnification steps until the maximum zoom size is reached. To decrease the magnification around the cursor , use the "/" key.

4.4 Layers (=)

Besides the zoom factor the number of the actual design layer is displayed. If you work with single layers only, you may leave the default setting "=ALL". But if you want to perform multi level lithography, please make sure that the suitable layer is selected before editing, calculating or exposing structure elements (Editor menu, Proximity menu, Exposure menu).

To select a layer, press the key "=" and enter the layer number or "a" for all layers. All elements edited within another layer will be displayed grey bordered.

The handling of design tools within different layers is explained in detail in chapter 6.

4.5 Contours

Sometimes it may become necessary to redraw the design field e.g. to show hidden lines (selectable via the display function "Show"). To redraw the design field, press the key "**C**". To redraw the design field at any time during PROXY operation use the hot key "Alt+**C**".

NOTE: Elements edited within another but the active layer are displayed grey bordered.

4.6 Doses

Press the key "**O**" to show a distribution of exposure doses. This function is used very frequently, therefore "Alt+**O**" is implemented as hot key to obtain a distribution of exposure doses at any time during PROXY or PROXY-WRITER operation.

NOTE: The dose distribution is displayed for elements within the active layer, only.

4.7 Help

To call up help, press the key "**H**". The help texts are stored in the files PROXY.HLP and PROXY-W.HLP. To display the next / previous page, use the arrow keys UP / DOWN.

5. Display Functions

To open the "Display" submenu, press the key "**D**" or click on the function's name. The submenu contains the following parameters and functions:

5.1 Show

To change the kind of element display, press the key "**S**" or click on the parameter's name. Available settings are "**S**how contours" and "**S**how hidden lines". Hidden lines are used to divide polygons into portions with convex shape or into grid cells. You have to carry out the "**C**ontours" function (or to use hot key "Alt+**C**") to activate a changed setting.

5.2 Cursor Display

To change the kind of cursor display, press the key "**C**" or click on the parameter's name. Available settings are "**C**ursor is small" and "**C**ursor is big". This setting will be activated automatically after leaving the adjustment menu.

5.3 Grid Display

To turn the grid display on or off, press the key "**R**" or click on the parameter's name. The grid divides the design field into portions for calculation. The grid step size can be defined by creating a new field via "New.", a submenu of the "**F**ile" command (see Section 6.3).

NOTE: This grid is not a design grid - an invisible design grid is selectable via the cursor step size.

5.4 Zoom Factor

The zoom factor defines the steps of the magnification when using the "*" key or the "/" key. A zoom factor of 3 causes magnification steps of 1, 3, 9, 27, ..., a zoom factor of 5 causes magnification steps of 1, 5, 25, 125, ..., etc.

To change the actual zoom factor, press the key "**Z**" or click on the parameter's name. Enter the appropriate value (1.1 to 32).

5.5 Dose Range (minimum, maximum)

The doses are indicated by 15 different colors, the range of the dose display can be set freely. The default dose range is 0 to 300 %.

To change the dose range, press the key "N" for minimum (or "X" for maximum) or click on the parameter's name. Enter the appropriate value.

NOTE: The dose range, defined by the minimum and maximum values, is automatically divided into 15 equal portions.

5.6 Grey Scale (Alt+G)

Normally a color palette is used to display an image but sometimes a grey scale is more natural. Pressing the key "**G**" allows you to change the colored dose scale to a grey scale or to monochrome color scales. It is especially useful for LAPTOP and NOTEBOOK computers with monochrome monitor. The hot key "**Alt+G**" may be used to change the display mode at any time during PROXY or PROXY-WRITER operation.

NOTE: Grey mode is not available for EGA monitors.

5.7 Get Dose (Alt+D)

PROXY allows to use almost infinite dose levels ranging from 0.1% to 3000% of the normal clearing dose.

To display a digital dose value on current cursor position press the key "**D**" inside the "**D**isplay" submenu or the hot key "**Alt+D**" at any time during PROXY or PROXY-WRITER operation. The assigned dose value appears at the top left hand side of the screen. The dose values of design elements will also be displayed if a TIF image or a simulated pattern is superimposed. Finally, press any key to return to normal operation.

6. File Functions

PROXY-WRITER handles files of different formats:

- **.GDB** - original format of PROXY (internal)
- **.ELM** - PROXY format for areas (ASCII)
- **.DXF** - for files created by DesignCad or other CAD systems
- **.CSF** - for the well known GDSII format
- **.LIT** - format for files generated by former ELPHY systems

To change the format of a file use the "." key or click the displayed extension.

GDB is the original PROXY format. Any imported file will be transferred automatically into a GDB file and can be called as such later. The area covered by the GDB will be created automatically according to the transformed data. All numbers in other CAD designs (e.g. DXF format) will be regarded as nanometer, and this may lead to a demagnification by a factor of 1000. When transfering a file, you will be asked to enter offset and scale values. Here the demagnification can be considered.

6.1 Load (Alt+L)

To load a file, press the key "**L**" or click on the function's name. Hot key is "**Alt+L**". Enter the name of an existing file without the extension (for example GDB or DXF). To display a list of all files with the indicated extension stored in the current directory, hit the ENTER key before typing a file name. You may select a file name from the list by mouse or arrow keys. Confirm your choice by clicking the left mouse button or by using the ENTER key. To load a file which is not stored in the current directory, type the complete path name leading to the directory.

NOTE: The length of the complete input string is limited to 25 characters.

6.1.1 GDB Format

During pattern import from other formats, the automatically selected GDB area will be divided into grid cells. The size of these grid cells is given by the value selected in the "New" function (default value is 20 µm).

The internal GDB format has been changed since version 94N (December 1994) allowing a more universal use. Former GDB files will be transformed automatically. In order to load a new GDB file by using an old PROXY-WRITER version, a transformation via ELM (see below) is required.

6.1.2 ELM Format

ELM is a special ASCII format, where the coordinates of all polygon corners are listed. PROXY uses only positive coordinates. Negative values characterise "hidden lines". Changing all negative signs to positive ones will transform all hidden lines into normal boundaries. ELM files can be called only by their absolute coordinates into an automatically created field. Universal operations using ELM files are possible via the Editor (see chapter 7).

Any standard editor (e.g. NOTEPAD.EXE) or spread sheet program, which is able to save data as ASCII text, may be used to create an ELM file "manually". The file format for ELM files is very simple:

- Rectangles, polygons, polylines and points may be edited.
- The number of elements is not limited.
- Each element block consists of a top line, coordinate lines (one line per corner) and the bottom line.
- The top line of each element block contains the type character (1 for rectangles and polygons, L for polylines, P for points), the dose, the layer number, and in case of polylines or points the thickness (not yet implemented in version 94N), all separated by a single space. There may be further numbers added, but these can be disregarded (they are scheduled for future applications, e.g. 3D proximity correction. When editing an ELM file, normally only the first character and the dose value are needed. Only for multi level lithography, the layer number has to be added.
- The coordinate lines contain the X and Y coordinates (one line per corner) separated by a single space.Each coordinate may consist of one or many digits.
- The bottom line of each element only contains the "#" sign.

The following example file was created by using Microsoft EXCEL.

The file contains four elements. All elements are assigned with 100% dose in layer 0 (in this case it is sufficient to consider just type and dose in the top line, when editing). Fig. 6-1 shows the structure after loading it by using the Edit / Read command.

```
1 100.000000
 1.000  5.000
 1.000  7.000
 3.000  7.000
 3.000  5.000
#
1 100.000000
 7.000  6.000
 6.000  5.000
 5.000  6.000
 6.000  7.000
#
L 100.000000
 1.000  3.000
 1.000  1.000
 7.000  1.000
#
P 100.000000
 7.000  2.000
 7.000  3.000
 6.000  3.000
 5.000  3.000
 4.000  3.000
 3.000  3.000
 2.000  3.000
#
```

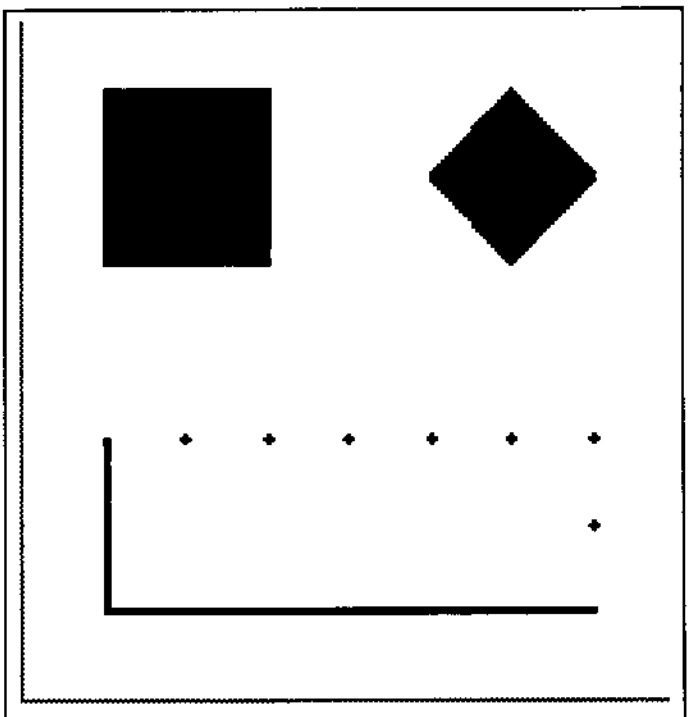

Fig. 6-1 Example for ELM File

6.1.3 DXF Format

The DXF file format is a standard data output format used by general purpose CAD systems. For lithography applications there is a specific pattern interpretation necessary as e.g. listed for the DesignCAD program in the table (see second and third column). The DXF conversion offers the facility to design especially curved polylines (arcs, curves) very easily by using any CAD program and to transfer them directly to PROXY. The table gives an overview for the conversion of different structure elements from DesignCAD version 6.0 via DXF format to PROXY format. Of

DesignCAD Version 6.0	**DXF**	**PROXY**
Line	Polyline	Polyline
Arc	Arc	Polyline
Curve	Polyline	Polyline
Box	Polyline	Box
Polygon	Polyline	Polygon
Circle	Circle	Circle
- - -	Solid	Polygon
- - -	Line	Polyline

course, any other CAD program with DXF export facility (AutoCAD, TechnoBox, etc.) may be used, too.

NOTE: Different CAD programs may generate different entity types within the DXF output file format starting from the same screen layout. For details refer to your CAD program manual.

The layer information will be taken over from DesignCAD (DXF format) to PROXY.

The DesignCAD program does not provide information whether a closed line is a polyline (border only) or an area (filled). PROXY transforms all closed lines (where the first point and the last point are identical) into areas. If you want to generate a closed line (border only) via DesignCad, the closed line has to be separated into two parts of open lines (e.g. two half circel lines instead of a full circle line etc.).

6.1.4 GDSII Format (CSF)

The hierarchical GDSII data base file format is used by CAD stations. GDSII files contain structures which may be referenced in other structures. They usually have the extension .CSF.

6.1.5 LIT Format

Previous ELPHY systems created LIT files, which describe the pattern in pixel without any absolute dimensions. For transforming into GDB format the size of one pixel has to be entered.

6.2 Save (Alt+S)

To save a file press the key "**S**" or click on the function's name. Enter a proper file name up to 8 characters. The extension determines the file format to be used for storage.

Standard format:	no extension (.GDB is added automatically),
DXF format :	type the extension .DXF,
GDSII format:	type the extension CSF.

NOTE: If you type the name of an already existing file, at the top left hand side of the screen the confirmation request "Overwrite '.....' (Y/N)?" appears, where '.....' contains the name of the file to be overwritten. Confirm overwriting by pressing the key "**Y**" or cancel saving by pressing the key "**N**" and start again with another file name. Whereas you may load files of many different formats, the "**Save**" function stores only GDB, DXF and CSF files (ELM and LIT files can be generated via the **W**rite function within the **E**ditor menu). Whenever you exit PW, you will be asked whether design changes should be saved or not.

6.3 New.

Press the key "N" or click on the function's name. The submenu NEW appears. Set the parameters of the new file using the commands "**B**ounds" and "Grid **S**tep". Finish with pressing the key "**C**" to create the new file with any name.

6.3.1 Bounds (Design Field Boundaries)

The boundaries of the design field are freely selectable. The default boundaries are:

- left X = 0
- down Y = 0
- right X = 20µm
- up Y = 20 µm

The coordinate origin of the default design field is located in the bottom left hand corner.

To change the boundaries of the design field, press the key "**B**" or click on the parameter's name.

NOTE: All border values have to be positive numbers. Entering a negative number causes an error message. The right border has to be greater than the left one (x2>x1) and the upper border has to be greater than the lower one (y2>y1). Otherwise an error message appears. It is not necessary in any case to set the left border and the lower border to zero.

Enter the appropriate values for left border, lower border, right border, and upper border.

6.3.2 Grid Step

The grid step size is important for simulation and correction - its default value is 20 µm.

To change it, press the key "S" or click on the parameter's name. Enter the appropriate grid step size.

The selected grid step within this menu is also valid for transfer of files from other CAD formats, but the total field size will be defined automatically.

NOTE: The changed parameter values are valid only for the new file to be created but not for the currently loaded file. To show the grid use the "show grid" function of the "Display" submenu.

6.3.3 Create

To create a new file press the key "**C**" or click on the function's name. Enter a freely selectable file name without any extension. The extension GDB will be added automatically.

NOTE: MS-DOS handles file names up to 8 letters, only.

If you type the name of an already existing file, at the top left hand side of the screen the confirmation request "Overwrite '.....' (Y/N)?" appears, where '.....' contains the name of the file to be overwritten. Confirm overwriting by using the "**Y**" key or cancel creation by using the "**N**" key and start again with another file name.

6.4 Print (Alt+P)

To make a hard copy of the screen image, use the "**P**" key or click on the function's name. At the top left hand side of the screen the confirmation request "Make sure your printer is ready. Start hard copy (Y/N)?" appears. Press the key "**Y**" to start or "**N**" to cancel the printout.

NOTE: Use the hot key "ALT+P" to print out the current screen image at any time during PROXY or PROXY-WRITER operation.

6.5 Printer Setup

Press the key "**U**" or click on the function's name to enter the parameters for printing. These parameters are:

6.5.1 Printer Type

To change the printer type, press the key "**P**" or click on the parameter's name. Available settings are "laser Printer" and "pin-wr. Printer".

6.5.2 Printout Format

To change the printout format, press the key "**F**" or click the parameter's name. Available formats are "full page Format" and "1/2 page Format".

In case of laser printer additional items in the menu appear:

6.5.3 Resolution

To set one of two values: *150 dpi* or *300 dpi* (dots per inch).

6.5.4 Grey scale

To set one of three values: *positive*, *negative* or *contrast*.

The *positive* mode gives a hard copy without black / white inversion. The *negative* mode inverts black / white scale (and normally saves toner). The *contrast* mode is useful for presentation of color exposure data.

6.5.5 Output Screen

To set one of two values: *screen* and *window*

Use the *screen* mode to print the whole screen and the *window* mode to print the design field, only.

6.5.6 Orientation

To set *portrait* (tall) or *landscape* (wide) mode of printing.

6.5.7 Left and Top Margins

To define the left margin and the top margin in cm

6.6 Squeeze File

During design of a structure some elements can be deleted, but PROXY does not reduce the volume of GDB files automatically. Press the key "**Q**" or click on the function's name to reduce the loaded GDB file.

6.7 Delete File

To delete a GDB file press the key "**D**". Enter the file name you want to delete. To display a list of all GDB files stored in the current directory, use the ENTER key before typing a file name. You may select a file name from the list by mouse or arrow keys. Confirm your choice by clicking the left mouse button or by using the ENTER key.

NOTE: Only files with the extension GDB can be deleted.

6.8 Parameters R/W

To save time, you may store application specific parameter values and settings in different parameter files.

To store a set of parameters, press the key "**W**" (write) or click on the function's name. Enter a file name containing up to 8 characters, but do not type the extension PAR.

To load a set of parameters, press the key "**R**" (read) or click on the function's name. Enter the name of an existing file, but do not type the extension PAR. To display a list of all PAR files stored in the current directory, use the ENTER key before typing a file name. You may select a file name from the list by mouse or arrow keys. Confirm your choice by clicking the left mouse button or by using the ENTER key. To load a PAR file which is stored in another than the current directory, type the complete path name leading to the directory.

The default file is "PROXY.PAR", which is loaded automatically after each program start. If you want to change the default values in PROXY and in PROXY-WRITER you should store them under "PROXY.PAR". But if you want to use application specific parameters you may store them under any name and call them when needed.

NOTE: There is only one parameter file containing all parameters for both program partitions (PROXY and PROXY-WRITER), but the parameters concerning PROXY (e.g. correction, simulation etc.) resp. PROXY-WRITER (e.g. time, field etc.) can be stored and recalled (File / Parameters R/W) **only**, if the corresponding program partition is active.

6.9 Exit (Alt+X)

To leave the PROXY or PROXY-WRITER program and return to DOS level, press the key "**E**" or click on the function's name. At the top left hand side of the screen the confirmation request "Exit, are you sure (**Y/N**)?" appears. Press the key "**Y**" to leave or "**N**" to stay.

NOTE: You may leave the program at any time using the hot key (**ALT+X**).

7. Editor

The PROXY editor can be used to design complete patterns without using other CAD systems or to modify an imported pattern (e.g. DXF or GDSII format).

The patterns can also be designed on an image background from the actual sample allowing you to write on specific areas of the structure (this is important e.g. for ion etching or induced deposition).

Besides the standard file format GDB, it is also possible to store and to load ELM files which are stored in a simple ASCII format and easy to understand. Such complete ELM files can be loaded by using the "File / Load" function, but it is also possible to store (Write.) sections of the pattern and to read (Read.) them again for placing them at different locations in a design field. Furthermore functions such as shifting, scaling, rotating in XY, and repeating with increasing dose etc. can be used to manipulate the ELM files before fixing them in the design field. Such manipulations are possible with small files which can be kept in memory with relative coordinates. Large ELM files have to be handled by absolute coordinates. Such files can still be scaled and shifted by using an offset.

While the "File / Load" function allows only loading of complete ELM files, the editor on the other hand allows that they can be generated too, e.g. for manipulation via ASCII editor.

Loading an ELM file via editor (Editor / Read) has the additional advantage to select any field size and to place the pattern anywhere inside the design field, while loading via file menu gives no such choice. For repositioning or rescaling of an existing pattern in GDB format, it is recommended to do this via storing an ELM file of the total pattern (Editor / Write) and then to load it again into a provided design field (Editor / Read).

The previous ELPHY systems work with LIT files, these were designed in a pixel format and not in absolute dimensions. Such complete files can be loaded via the "File / Load" function by defining the pixel size.

Using the editor, it is also possible to load small LIT files in relative coordinates for manipulation in the same way as ELM files.

7.1 Dose

Below the menu name (EDITOR), the actual dose value is displayed. This dose is given to the next structures which you will design, until you change its value.

To do so, press the key "**O**". Enter the appropriate dose value.

NOTE: This procedure will not change the dosage of already existing structure elements. Changing of doses is possible via postprocessing (see chapter 8)

7.2 Box

Before editing a box, the layer has to be selected. All elements edited within another layer will be displayed grey bordered. If all layers are selected (keys "**=**", "**a**"), the box will be edited within **layer 0**.

To draw a rectangular box, press the key "**B**" or click on the function's name. Move the cursor to one corner of the rectangle you want to create and hit the space bar or click the left mouse button. Move the cursor to the opposite corner of the rectangle you want to create and use the ENTER key or click the left mouse button to confirm.

7.3 Contour

Before editing a polygon (= filled area), the layer has to be selected. All elements edited within another layer will be displayed grey bordered. If all layers are selected (keys "**=**", "**a**"), the polygon will be edited within **layer 0**.

To draw a polygon with or without an internal hole, press the key "**C**" or click on the function's name.

- Move the cursor to the first corner of the polygon and hit the spacebar or click the left mouse button.
- Move the cursor to the other corners one by one, hitting the spacebar or clicking the left mouse button at each of them.
- Use the ENTER key or click the right mouse button to close the polygon.
- At the bottom right hand side of the screen the message "Internal" appears. If you want to cut a hole in the polygon, you have to confirm this message by pressing the key "**I**". Otherwise you may cancel this option by using the ENTER key or the Esc key.
- After confirming the message "Internal" by pressing the key "**I**", move the cursor to the first corner of the hole inside the polygon and hit the spacebar or click the left mouse button.

- ⇨ Move the cursor to the other corners one by one, hitting the spacebar or clicking the left mouse button at each of them.
- ⇨ Use the ENTER key or click the right mouse button to close the hole.
- ⇨ Once again the message "Internal" appears. Confirming it by pressing the key "**I**" allows you to create another hole inside the same polygon, but not inside the first hole. Otherwise an error message appears at top left of the screen. As long as you confirm the message "Internal" by pressing the key "I", you may create holes inside your polygon, but make sure that these holes do not overlap each other.

7.4 Polyline

Before editing a polyline, the layer has to be selected. All elements edited within another layer will be displayed grey bordered. If all layers are selected (keys "**=**", "**a**"), the polyline will be edited within **layer 0**.

While boxes and polygons are written as areas, polylines are written as borders only, even if they build up a closed structure.

The mathematical width of a polyline is zero. Its physical width is 1 pixel ("Single Pixel Line") that means the diameter of the writing device (electron beam etc.).

To edit a polyline press the key "**L**" and hit the space bar or click the left mouse button at each corner of the polyline (like for Contours, see section 7.3). Finally, hit the "Enter" key or click the right mouse button to confirm the last point of the polyline.

The handling of polyline exposure is described in detail in sections 11.2 to 11.4.

7.5 Points

Before editing points, the layer has to be selected. All elements edited within another layer will be displayed grey bordered. If all layers are selected (keys "**=**", "**a**"), the points will be edited within **layer 0**.

While boxes and polygons are written as areas, points are written as borders only, even if they build up a closed structure.

The mathematical width of a point is zero. Its physical width is 1 pixel that means the diameter of the writing device (electron beam etc.).

To edit a couple of points press the key "**P**" and hit the space bar or click the left mouse button at each location where a point is to be set. Finally, hit the "Enter" key or click the right mouse button to confirm the last point.

The handling of points exposure is described in detail in sections 11.2 to 11.4.

7.6 Delete

Before deleting structure elements, the layer has to be selected. If all layers are selected (keys "=", "a"), all structure elements may be deleted.

To delete elements, press the key "D" or click on the function's name. Draw a frame around the elements you want to delete.

> NOTE: The elements have to be surrounded completely by the frame. To delete elements which are only touched by the frame, use (Shift+D).

To delete all elements inside the selected layer within the entire design field, press the key "D" and use the ENTER key twice. At the top left hand side of the screen the confirmation request "Select all. Are you sure? (Y/N):" appears. Press the key "Y" to confirm or "N" to cancel.

7.7 Read.

The function is used to read and manipulate patterns which were created earlier by PROXY (ELM format) or by ELPHY (LIT format).

To open the "Read" submenu, press the key "R" or click on the function's name. The submenu contains the following parameters and functions:

7.7.1 File format is LIT / ELM

To toggle between the LIT and the ELM format press the key "F" or click on the function's name. The ELM files are very useful for universal editing, while the LIT files have only importance in connection with former ELPHY versions. Make sure that there is a working field created, which can cover the full pattern (this is different from handling via the file manager, where the fields are created automatically).

7.7.2 Coordinates are relative / absolute

To toggle between relative and absolute coordinates press the key "C" or click on the function's name.

7.7.3 Read

ELM files allow to transfer structures from any level of one GDB file into any level of another GDB file. For doing that the proper layer in the actual design field has to be selected and the "Read / Layer" command has to be used.

If an ELM file with all layers (Layer=all) will be transferred into the actual design where also all layers are activated, the ELM structures will be automatically assigned to the corresponding layers as described in the ELM file. If a certain layer of the read ELM file is selected, only the structures within this layer will be considered.

If there is a special layer selected in the actual design field, the selected ELM structures will be read into the activated design layer independent of the ELM layer. If all ELM layers are activated, but only one layer in the actual design, the ELM structures of all layers will be read into this single design layer.

Reading in absolute coordinates

Press the key "**R**" or click on the function's name. Enter the name of an existing file without extension. To display a list of all files with the indicated extension stored in the current directory, hit the ENTER key before typing a file name. You may select a file name from the list by mouse or arrow keys. Confirm your choice by clicking the left mouse button or by using the ENTER key. To load a file which is not stored in the current directory, type the complete path name leading to the directory.

If the selected file format is ELM, enter the appropriate value of x-offset (µm), y-offset (µm), scaling factor along x- and y-axes, or hit ENTER before typing, to accept the default value.

The structure stored in the ELM file will be scaled, shifted and then added to the existing picture.

If the selected file format is LIT, you will be just asked to enter the size of one pixel.

Reading in relative coordinates

This mode gives more possibilities in manipulating with inserted elements than the previous one. It allows to rotate, to repeat, to mirror and to use different scale factors along the x-axes and y-axes.

After entering a file name a menu appears:

- *Pattern position **X / Y***

After all these operations the pattern is still movable, its coordinate origin coincides with the position of the cursor cross. You may change the position of the pattern by moving the cursor using the arrows keys, the mouse or by hitting the keys **X** or **Y** for digital input.

Scale

Press the key "**S**" or click on the function's name. Enter the appropriate value for X-scale and Y-scale, or hit ENTER before typing, to accept the default value.

Repeat

To repeat a pattern, press the key "**R**" or click on the function's name. Enter the appropriate value for X-start (µm), Y-start (µm), horizontal and vertical repetition, X-offset, Y-offset and dose factor, or hit ENTER before typing, to accept the default value.

Rotate

Press the key "O" or click on the function's name. Enter the appropriate rotation angle (degree).

Horizontal mirror

To mirror the pattern along a horizontal axis, press the key "**H**" or click on the function's name.

Vertical mirror

To mirror the pattern along a vertical axis, press the key "**V**" or click on the function's name.

NOTE: After completing all changes to the pattern, use the ENTER key to accept the pattern or press the Esc key to cancel the Read procedure and all changes to the pattern.

7.8 Write.

Before writing (storing) complete structures or marked parts of them, the layer has to be selected. If one layer is selected, only the structures within this layer will be considered (this is only valid for ELM files - LIT files will always be written completely). If all layers are selected (keys "**=**", "**a**"), all structures or marked parts of them within all layers will be written. The layer info will be stored within the written file for later reading.

To open the "**Write**" submenu, press the key "**W**". The submenu contains the following parameters and functions, depending on the selected file format.

7.8.1 File format is LIT / ELM

Press the key "**F**" or click on the function's name to toggle between LIT format for transferring to ELPHY and ELM format for work with PROXY.

7.8.2 Relative or absolute Coordinates (for ELM files only)

Press the key "**C**" to toggle between relative and absolute coordinates. Absolute coordinates are related to the left bottom corner of the field, while relative coordinates count from the left bottom corner of any drawn frame. The file will get always the extension **ELM**. The method of storing (writing) is completely independent of the method for calling (reading).

7.8.3 Write (ELM)

Press the key "**W**" or click on the function's name. Draw a frame around the elements you want to write and confirm by hitting the ENTER key (to write all elements within the entire design field hit the ENTER key twice). Enter an appropriate file name.

NOTE: The elements have to be surrounded completely by the frame.

7.8.4 Output lines / boxes & triangles (for LIT files)

Press the key "**O**" or click on the function's name to toggle between the modes. The mode "*boxes & triangles*" means the structure will be divided into boxes and triangles in such a way that these elements precisely cover the structure without slots and overlapping. In case of the mode "*lines*" the structure will be stored as small rectangles with the height of one pixel (according to the selected bit resolution). This mode is not recommended and only useful in very special cases, because it is very time consuming.

7.8.5 Write (LIT)

Press the key "**W**" or click on the function's name. Enter an appropriate file name, the resolution (bit) and the pixel size (µm) or hit the ENTER key before typing to accept the default value.

7.9 Background.

If a pattern has to be written exactly on one place of the sample by ion etching or in resist with low sensitivity, an image of the area of interest can be taken as a background for design (it needs alignment capabilities to get the video image - see chapter 12, Alignment).

To open the "background" submenu, press the key "**G**" or click on the function's name.

To load a background image, press the key "**L**". Enter the name of an existing file without extension.

NOTE: Only TIF files can be used as background images.

To display a list of all files with the extension TIF stored in the current directory, hit the ENTER key before typing a file name. You may select a file name from the list by mouse or arrow keys. Confirm your choice by clicking the left mouse button or by using the ENTER key. To load a file which is not stored in the current directory, type the complete path name leading to the directory.

NOTE: Make sure that the design field is large enough: The loaded TIF file needs at least the same field size as it had when it was created.

You can zoom in on any location for designing any pattern via the editor allowing you to position the structure very precisely.

A file stored with extension TIF may contain several TIFF images (e.g. several marks). To look at single images, press the key "**A**" until the setting "show one mark" appears and call the images one after the other by pressing the key "**C**".

To show or to hide the background image press the key "**B**".

The functions "Auto **P**alette" and "User Palette" (mIn, **M**ax) are described in detail in section 12.4.

7.10 Tools.

The Tools submenu provides useful design elements like **T**ext strings, **R**ing elements and **C**ones. To open the "**T**ools" submenu, press the key "**T**" or click on the function's name.

Before editing text strings, ring elements or cones, the layer has to be selected. All elements edited within another layer will be displayed grey bordered. If all layers are selected (keys "**=**", "**a**"), the elements will be edited within **layer 0**.

7.10.1 Text

After entering a text string, it can be placed anywhere inside the pattern. It can be scaled differently in X and Y, rotated, repeated and mirrored in horizontal and vertical dimension. Confirm the final position by hitting the ENTER key.

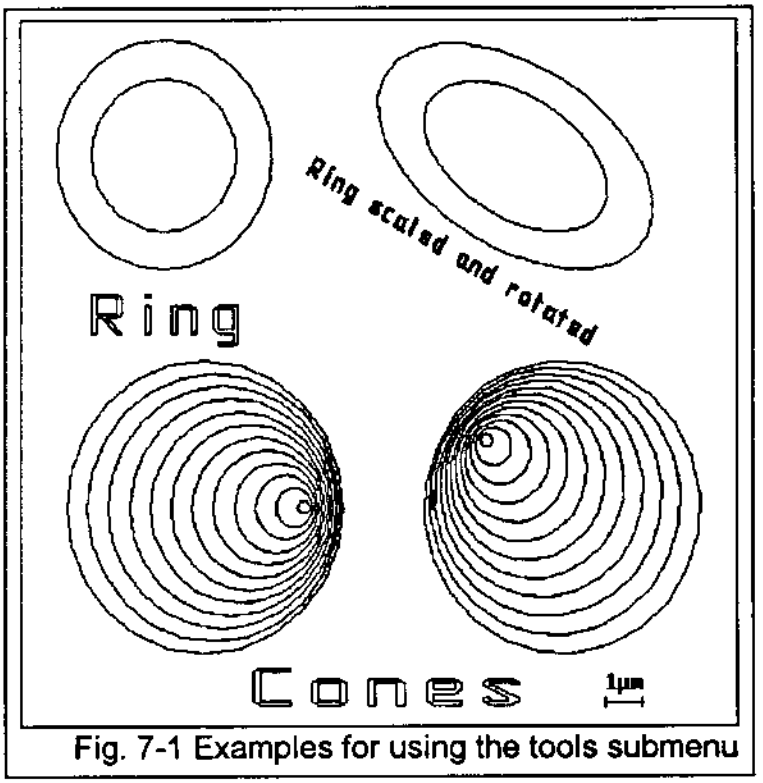

Fig. 7-1 Examples for using the tools submenu

7.10.2 Ring

This function allows you to generate rings. Enter just inner and outer radius and hit the ENTER key. To design a full circle, set one radius equal to zero. The ring element can be scaled to ellipses, rotated etc. and finally confirmed by hitting the ENTER key.

7.10.3 Cone

Straight or inclined cones can be produced by superimposing circles of different sizes and locations. Enter R1 (bottom radius), R2 (top radius), Dcent (distance between centers) and Nlev (number of total levels). Proceed as usual.

8. Postprocessing

Postprocessing allows you to do many automatic modifications in given structures, e.g. for proper proximity correction or other purposes.

> NOTE: Most of the postprocessing functions can not be applied to polylines or points as they have the mathematical width zero.

To open the "postprocessing" submenu, press the key "T" or click on the function's name. The submenu contains the following functions:

8.1 Negative

To transform the structure to negative tone inside a frame. All doses will be set to 100%.

8.2 Union

To unify substructures leaving just the outer contours. All doses will be set to 100%. The minimum working area for unifying is one full cell of the calculation grid. This function removes all overlapping.

8.3 Frame..

To provide a small frame inside the border of all structure elements. Width and additional dose inside the frame are selectable after pressing "Ctrl+F" or clicking the two points behind the function's name. This function is mainly used for alpha correction.

> NOTE: To divide the frame into squares at the corners and rectangles along the edges, use a negative sign for the frame width.

8.4 Shrink..

To shrink or to grow (negative sign) all structure elements by any amount. A shrinking factor is selectable after pressing "Ctrl+S" or clicking the two points behind the function's name. All doses will be set to 100%.

8.5 Erase

To erase structures inside any drawn polygon (it cuts features).

8.6 Dose Set

To change the dose of already existing elements, press the key "**T**" or click on the function's name. Enter the appropriate dose value. Draw a frame around the wanted elements and confirm by using the ENTER key.

NOTE: The elements have to be surrounded completely by the frame.

To change the dose of all elements within the entire design field, proceed as usual until the request "Select area.." appears. Then hit the ENTER key twice instead of drawing a frame.

8.7 Dose Scale

The dose of already existing elements may be multiplied by a freely selectable factor greater or less than 1 (scaling up or down). To do so, press the key "**C**" or click on the function's name. Enter the appropriate dose scaling factor. Draw a frame around the wanted elements and confirm by using the ENTER key. The maximum dose value is limited to 3000%.

NOTE: The elements have to be surrounded completely by the frame.

To scale the dose of all elements within the entire design field, proceed as usual until the request "Select area.." appears. Then hit the ENTER key twice instead of drawing a frame.

8.8 Dividing..

Before dividing an element into substructures, check all options:

Press "Ctrl+**V**" or click on the two dots behind the function's name. Press the key "**V**" several times until the wanted mode appears. Available modes are: *grid / rects & triangs / trapezes / horiz. trapezes / vert. trapezes.*

With *grid* any part of the pattern can be substructured by a selectable grid for proximity correction in fixed regions.

To divide an element into substructures, press the key "V" or click on the function's name. Draw a frame around the wanted elements and confirm by using the ENTER key.

To divide all elements within the entire design field, proceed as usual until the request "Select area.." appears. Then hit the ENTER key twice instead of drawing a frame.

8.9 Overlaps Out

To extract overlapping structures and to show total dose at each place. At each point the doses of all superimposed structures will be added. This function is different from "overlap removal", which will be done automatically during proximity correction (by using variable shapes) or by the "Union" function.

8.10 Distortion

If the SEM shows distortion in large writing fields the pattern can be adapted to it. First the distortion has to be measured using an SEM test sample (e.g. CHESSY) and by using the alignment features of PROXY-WRITER (allowing you to read the structure from small selected fields for measuring the deviations). These results have to be written in a distortion matrix file with extension DST by using any ASCII editor according to the example on the following page.

In this example the distortion matrix contains 5 * 5 points as stated in the first line. After the first "#" sign all scheduled X coordinates of this matrix are listed, and after the second "#" sign all scheduled Y coordinates are listed. There are two "#" signs after the definition of the scheduled matrix (these are the positions in case that there is no distortion). The following five groups of data are the real positions which occur due to distortion, each with the exact X and Y coordinates. The first group of data corresponds to the scheduled X coordinate "2" and covers the scheduled points 2/2, 2/6, 2/10, 2/14 and 2/18. The other blocks correspond to the scheduled X positions of 6, 10, 14 and 18.

For an ideal distortion correction each structure has to be divided into infinite substructures which is, of course, not practicable. Therefore the wanted substructuring can be defined by the selected grid size. The example gives a distortion matrix inside a 20 micron field (this is not realistic - it is just an example). In order to transform a pattern with this distortion matrix, it is recommended to use a 20 micron field with 1 micron grid size. In real life, a distortion correction may be necessary within a 1 mm writing field, and then a 20 micron or 50 micron subdivision would be fully sufficient. The measured distortion matrix may cover 11*11 points measured with CHESSY in 100 µm intervals.

To introduce a distortion matrix to the program proceed as follows:

Press the Ctrl+D keys or click the left mouse button on the two points behind the function's name. The message "Distortion is off" appears on top of the screen.

Press the key "D", the request "Enter file name [.DST]" appears.

Enter the name of an existing distortion matrix file. To display a list of all distortion matrix files stored in the current directory, hit the ENTER key before typing a file name. You may select a file name from the list by mouse or arrow keys. Confirm your choice by clicking the left mouse button or by using the ENTER key. To load a file which is not stored in the current directory, type the complete path name leading to the directory.

NOTE: The length of the complete input string is limited to 25 characters.

Finally, press the key "D" or click on the function's name to perform correction of distortion.

```
5 5
#
2
6
10
14
18
#
2
6
10
14
18
#
#
1.095 1.095
1.284 5.642
1.36 10
1.284 14.358
1.095 18.905
#
5.642 1.284
5.774 5.774
5.84 10
5.774 14.226
5.642 18.716
#
10 1.36
10 5.84
10 10
10 14.16
10 18.64
#
14.358 1.284
14.226 5.774
14.16 10
14.226 14.226
14.358 18.716
#
18.905 1.095
18.716 5.642
18.64 10
18.716 14.358
18.905 18.905
```

9. Proximity Effect

The proximity effect is mainly caused by electrons which are back scattered from the substrate leading to a second resist exposure from underneath, which is diffuse and strongly depending on the exposed areas nearby - on the "proximity". Additional effects are caused by electron forward scattering in resist and by the resist development itself.

Correction and simulation of proximity effects can only be done with known proximity parameters corresponding to the "Two Gaussian Function". These parameters are:

- Alpha, describing the distribution of forward scattering (below 1 µm),
- Beta, describing the distribution of back scattered electrons (above 1 µm) and
- Eta, describing the contribution of back scattered electrons to the exposure, which is in the same order as the exposure by primary electrons (the value is below or above 1).

PROXY allows to measure these parameters for any substrate (see section 9.4).

NOTE: Proximity correction and simulation is possible only for structure elements within the active layer. Polylines and points are not suitable for proximity correction and simulation. Use thin contour lines instead.

9.1 Basic Proximity Correction

This basic correction is very easy to handle. Like other methods for proximity correction it requires a suitable substructuring, which can be provided by postprocessing, and the input of the above mentioned three proximity parameters. The correction will be calculated in one step giving each substructure element its optimum dose.

The parameters **Alpha**, **Beta** and **Eta** are described in section 9.4. The parameters **X**-step and **Y**-step are described in section 9.2.3.

9.1.1 Start

To start basic correction, press the key "**S**" or click on the function's name. Draw a frame around the wanted elements and confirm by using the ENTER key.

To provide basic correction for all elements within the entire design field, proceed as usual until the request "Select area.." appears. Then hit the ENTER key twice instead of drawing a frame.

9.2 Full Proximity Correction

The full correction combined with simulation and parameter determination allows unique and fundamental studies with lots of variations, but it needs a detailed understanding and deep involvement to get full benefit out of it.

To set all parameters for full correction press "Ctrl+F" or click on the two dots behind the function's name. Following parameter settings are required:

*9.2.1 **Alpha, Beta, Eta***

These parameters are described in section 9.4.

*9.2.2 **Number of Zones (N)***

Using full correction, PROXY calculates also the optimum shape of zones with different doses depending on Beta. N defines the number of calculated zones, which can be set between 1 and 10. The dose of each zone is shown in the level table (to be called by pressing the key "**L**") and can also be changed there (for input in level 10 use "0").

*9.2.3 Exposure Step Sizes (**X**-step, **Y**-step)*

These step sizes in X and Y are normally set to 1 nm. Only in cases when small lines and areas will be written with just a few exposure dots it is recommendable to do the correction exactly for this special exposure mode with larger steps.

9.2.4 Type: (Simple Compensation / Iteration)

The parameter "**Type**" offers the *simple compensation* in one step (like for basic correction, but including zone shape calculation) or a correction in a selectable number of *iterations* leading to self-consistent dose distributions.

9.2.5 Fix: (Isoline Levels / Regions)

The parameter "**Fix**" offers choices where either fixed *regions* are used (provided like in basic correction or calculated by simple compensation) giving each zone or element the optimum dose - or the doses are fixed for N zones and the zone boundaries (*isolines*) will be changed with each iteration step getting stable after approx. 5 iterations.

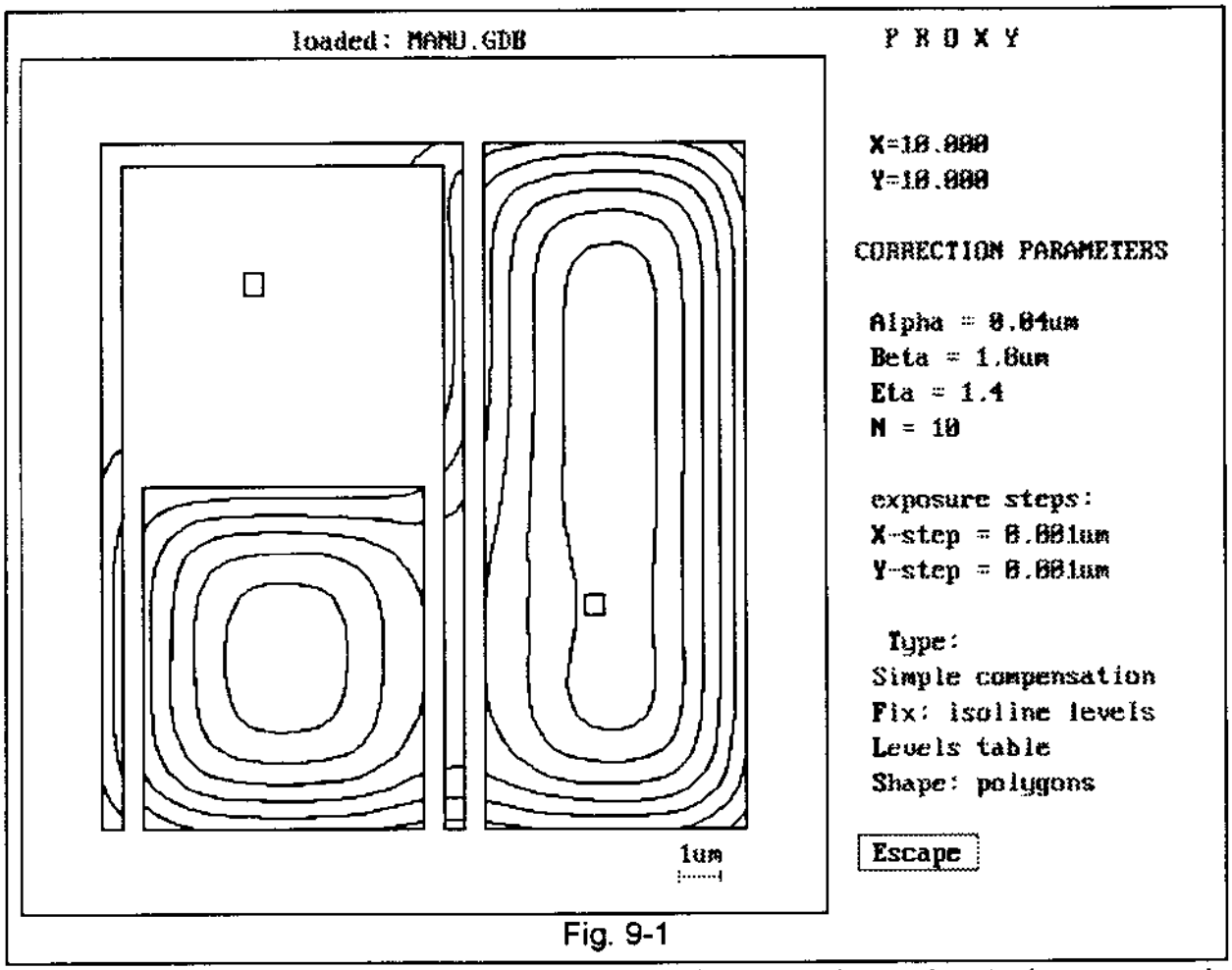

Fig. 9-1

Fig. 9-1 shows a structure, which needs proximity correction at least when exposed on GaAs. Gates, gaps, dot and hole are 0.5 µm wide.

This structure has been corrected for GaAs and 30 keV (Alpha = 40 nm) - there are several calculated zones, separated by isolines, which need different doses between 103% and 235% related to the "clearing dose" needed for large areas.

In the latter case "Shape" gives the choice of dose zones separated by polygon isolines (suitable for direct exposure by PROXY-WRITER) or by rectangular isolines (for dividing into rectangles). All corner points will lie in a grid defined by exposure steps.

9.3 Proximity Effect Simulation

The result of the proximity effect after development can be simulated. This is of interest for uncorrected structures in order to see whether proximity correction is needed, but also for corrected structures in order to check the quality of correction. When the simulation is done with the same parameters used before for correction, then it still can show effects caused by insufficient substructuring and it shows in addition the influence of resist development.

The submenu of simulation parameters is similar to that for correction in respect of Alpha, Beta, Eta and the exposure steps.

"N" has a different meaning here. The full resist thickness H0 is divided into N thickness levels allowing to display the remaining resist thickness after development. Default levels are equally spread over the whole range, but this can be changed via the level table.

PROXY simulation calculates also the influence of resist development. Therefore it is necessary to enter the information about the Resist type (pos. / neg.), its thickness H0 and its contrast Gamma (=2 for PMMA). The calculation of the resist effect can be suppressed by setting H0 to zero (dividing into N levels is still possible).

NOTE: The time for simulation is much shorter, if Alpha and H0 are set to zero. Otherwise it is recommended to simulate only small portions of the pattern.

9.4 Parameter Determination

There are several methods for parameter determination which use strongly overexposed test structures. In such cases the process of resist development may have a strong influence on the result (especially for PMMA).

The PROXY parameter determination avoids any overexposure in critical areas and in contrast to all other methods it uses patterns with calculated dose distributions. In this way Alpha and Beta can be measured independently, just Eta has to be measured by structures calculated with known values for Alpha and Beta.

9.4.1 Alpha Test Pattern

The Alpha test pattern consists of many lines with increasing thickness, starting with a thickness smaller than Alpha. The doses in all lines are calculated by proximity correction for a given Alpha value allowing full exposure of all lines assuming the given value is true. In vertical (Y) direction all lines are split in small sections where the dose values decrease by 5% in each step. In case the Alpha value used for calculation is true, all vertical lines will end in the same height forming a straight hori-

zontal boundary. If the Alpha value is smaller than expected, the thin lines will be longer and vice versa.

Via the submenu "Parameter" such patterns can be calculated for many different Alpha values and all of them can be exposed at once. After exposure the pattern with the most straight boundary shows the "true" Alpha value. The program allows you also to simulate how the pattern would look like when the real value is different from the assumed value.

9.4.2 Beta Test Pattern

In this case, thin central lines are influenced by overexposed structures on both sides and in different distances. Also this patterns will be calculated by given Beta values. Here you should look only for a straight boundary formed by the inner lines. This Beta test is independent from Alpha and Eta, allowing to measure Beta in one step together with Alpha.

9.4.3 Eta Test Pattern

The Eta test pattern is similar to the Alpha test pattern but it is going up to thicknesses larger than Beta. For calculating this pattern the values for Alpha and Beta must be entered. Using simulation, all effects of altered parameters can be studied, which allows you to find true parameters by adaptation of the simulated curve to a measured curve, which is not straight. Such a procedure could save a lot of time.

9.4.4 Hints for Generation of Test Patterns

Depending on the used technology, the possible values for Alpha and Beta are in a limited range. Therefore it is possible to create a special test pattern, which allows to determine Alpha and Beta with only one exposure shot. After that several test patterns for Eta can be designed in one exposure field with different Eta values by using the measured values for Alpha and Beta.

The parameter determination menu allows to generate always only one test pattern for one set of parameters, and this can be stored as a GDB file. After creating e.g. several GDB files for several Alpha or Beta values, you may store all of them as ELM files, and then you will have the possibility to arrange all patterns in a large design field (do not scale the ELM files because this will lead to wrong results). The used design field should still allow to achieve the wanted resolution. It is recommended to leave the middle of the field free, in order to use this for focusing at high magnification.

NOTE: The measured Alpha value depends strongly on the quality of focusing.

Below some parameter values are given for Silicon and GaAs, which were measured using this method (Alpha is not listed because it depends on individual beam diameter, resist thickness and beam energy, but it does not influence Beta and Eta very much, if the resist is not too thick):

Silicon with 0.5 micron PMMA
Eta = 0.75 (independent of energy)
Beta = 0.9/ 1.4/ 2.2/ 2.8/ 4.0/ 5.8
keV = 11 / 15 / 20 / 25 / 30 / 35

GaAs with 0.5 micron PMMA
Eta = 1.4 (independent of energy)
Beta = 0.7/ 1.0/ 1.3/ 1.8/ 2.2/ 2.6
keV = 15 / 20 / 25 / 30 / 35 / 39