MICROTECH LASER WRITER

Specification

- **Equipment compatible with 3",4"and 5" mask plates.**
- **Gallium Nitride Diode Laser (405nm).**
- **The illumination by a red source (= 640 nm) to which both resist and photo-emulsions are not sensitive.**
- **Writing area up to 4" X 4".**
- **5000 Angstrom Iron Oxide mask plate.**
- **3100 Angstrom Photoresist**
- **Resolution: 4um for lens 5,**

  10um for lens 4.
- **Field of view after development: upto 100um**
- **Software Package: LaserDraw-2D**
- **Design Software: Clewin**

LASERWRITER LW405

LASER PATTERN GENERATOR

RESEARCH AND DEVELOPMENT

LaserDraw-2D

OPERATING SOFTWARE FOR LASERWRITER

(release 6.2 - 2007)

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LASERWRITER LW-405
Laser pattern generator for research and development

Introduction

The LaserWriter (LW) system is a low-cost and high performance solution for patterning planar structures on a mask or directly on the final substrate. Rapid prototype fabrication or low-volume productions are typical applications. The list below describes the units that compose the LW and their function.

- The **write unit** allocates the GaN or Helium-Cadmium laser, the substrate microtranslation system, the laser interferometer (optional), the electro-optical components for modulating the laser beam and regulating the exposure energy.
- The **vibration damped legs frame** is used for floor installation. It can also allocate the control electronics just below the write unit, resulting in a total system footprint of just 75 x 75 cm.
- **Cabinet**: it encloses the write unit, creating a protected environment around the LW, mainly against the fast air flow of the clean room, that may induce vibrations.
- **Vacuum pump**: this firmly holds the substrate on the chuck during pattern generation.
- The **control unit ,** is made of:
  - **Laser power supply** (for Helium-Cadmium laser only).
  - **System control unit**: this includes the user-interface computer (LWØ), the write-control computer (LW1) and the XYZ stage controller (LW2). A further computer (LW3) controls the interferometer (if installed), and is directly allocated on the right wall of the write unit.
  - **Beam modulation driver** (for He-Cd laser only).
  - **Uninterruptible power supply**.

Several cables interconnect the different units. All operations are controlled by the LaserDraw-2D software package, distributed among the LWØ, LW1, LW2 and LW3 computers. A sketch of all interconnects is reported at the end of this section of the manual.

The LW is designed for full automatic operation, with limited operator tasks, such as inserting the substrate in the writing unit, start the focusing procedure, select the exposure level. The LW control procedures also allow a full manual operation mode, for using the system as a surface inspection and measurements station.

All parts used for mechanical translations are made with top quality components, in order to minimize wearing and assure a long-term stability of the system specifications.

The XY translation stage, used for moving the samples under the laser beam, is made of state-of-the-art linear motors and optical linear encoders. It is set for moving at a speed not higher than 10 mm/s and has a resolution of 10 nm. The positioning precision of the stages relies on the precision of the linear optical encoders installed in the unit. If the system includes a laser interferometer, the overall positioning precision is based of the interferometer reading.

The interferometer, when installed, includes a Helium-Neon laser, two optical signal pickup blocks, two optical links and two signal receivers. Also, a couple of long mirrors is connected to the moving substrate holder. **Do never touch the mirror surface or clean it**.

As a high precision system, it is important **not to use the system for purposes different than those it is designed for**. In order to get the best results from the LW system, the operators should be familiar with the following topics:

- optical microlithography;
- microcontamination control;
- environmental microvibration control;
- operating techniques in clean-room.

Please feel free to contact MICROTECH for any information or advice on such topics (fax: +39-091-730-7911, e-mail: mail@microtechweb.com).

Operating environment and installation

It is strongly recommended to install the whole system in a clean room, avoiding its use in normal offices or laboratories, even for a limited period. A stay in such environments can generate a high level of microparticle contamination on the substrate holder and in the work chamber of the writing unit, as well as in the electronics contained in the control unit. This contamination can be very hard to remove if the system is later placed in a clean-room. Moreover, an installation in clean room minimizes the substrate contamination when it is moved from its container to the LW. The clean-room class must be compatible with the required minimum linewidth in the pattern.

Note: the LW is assembled in a class 100 environment. Since the electronics contained in the control unit has internal forced air cooling, it is advisable to start the system only after establishing the clean-room operative conditions. A temporary heap of particle contamination in the electronic systems will later be slowly released in the operating environment.

To achieve quality patterns from the LW, in terms of resolution and precision, **the operating environment must also be free of strong vibration sources**, such as mechanic or cryogenic vacuum pumps, air compressors and other devices capable of generating low frequency (<100 Hz) acoustic pollution.

The system is powered with 220 V, 50Hz (115 V, 60 Hz optional) single phase (max 400W with GaN laser and max 800 W with He-Cd laser), through an Uninterruptible Power Supply (UPS).

W A R N I N G !

BE SURE THAT THE PLUG USED FOR THE UPS IS CONNECTED TO AN EFFICIENT GROUNDING SYSTEM

The system allows voltage fluctuation up to ±20% and it has filters for electric noise. However, it is recommended to keep the power phase of the control unit free from strong **voltage transients** (such as those generated by refrigerator compressors of conditioning systems) and **strong electromagnetic noise sources** (such as switching high power controllers, brush motors, etc.).

It is also recommended to avoid **electrostatic sparks** arising within 5 m from the system, as those generated by polyester, cotton and wool material (avoid to wear overalls not containing conducting wires for dissipating the static electricity).

Once the environment is defined, the installation can start. Normally, MICROTECH's technicians install the system in presence of the future operators.

WARNING: DO NOT START THE LASERWRITER IF ONE OF THE FOLLOWING CONDITIONS OCCURS:

- **Disconnection of one or more earth cables from the cabinet frame.**
- **Disconnection or inaccessibility of the red button for the emergency STOP.**
- **Cabinet removed.**
- **Opening of one of the electronic systems contained in control unit.**
- **Protective parts removed (those with "LASER RADIATION" indication).**

MICROTECH IS NOT LIABLE IF THE ABOVE CONDITIONS ARE NOT OBSERVED.

W A R N I N G !

Before operating inside the LASERWRITER units ALWAYS DISCONNECT THE 220 V (or 115 V) MAINS AND DEACTIVATE THE UNINTERRUPTIBLE POWER SUPPLY.

The write unit

The write unit is the main part of the LW. It handles the laser beam through specialty optics tuned to the laser wavelength, and provides for intensity regulation, modulation and scanning.

The laser radiation is sent onto the substrate through a final focusing lens placed in the upper part of the work chamber. Different focusing lenses are allocated on a moving platform with stops (if installed) and are user selectable. The operator can choose among the following stop positions:

#2 - Low resolution lens (NA limited to 0.12). This position is usually used for large field substrate inspection and not for writing, as the low NA value lens corresponds to a minimum achievable linewidth around 8 µm, which is too large for most applications.

#3 - Medium resolution lens, with NA = 0.25. Besides surface inspection, this position can be used for writing. This medium resolution lens allows a minimum linewidth of about 4 µm.

#4 - High resolution lens, with NA = 0.4. Besides surface inspection, this position is best suited for writing, because it allows a linewidth around 2 µm.

#5 - Max resolution lens (NA = 0.65). In this position writing occurs with the maximum optical resolution (1 µm linewidth or better, limited by proximity effects in the photoresist).

#6 - Spare position, for future optical accessories.

All other positions are conventionally indicated as #1, with no mechanical stop and no lens. **For easily loading and unloading of the substrates, it is recommended to push the platform until all lenses are away from the vacuum chuck, and use the *LOAD/UNLOAD* commands in the software interface .**

A specific optimal drawing speed corresponds to each selected resolution, that is to the selected final focusing lens (#3, #4, #5). The lower the resolution, the faster the writing speed than can be set. As explained further on, this speed can be chosen through a *D-step* parameter.

A CCD camera allows substrate observation for focusing before the write process or for surface inspection and videomicroscopy. The illumination of the substrate is given by a red source (= 640 nm) to which both resist and photo-emulsions are not sensitive.

Focusing can be performed through different approaches, according to substrate condition. The knowledge of the substrate plane can be used, as well as an optical surface track method or the analysis of the image of a knife-edge projected on the substrate, as described in the next section.

The lower part of the optical head allocates an XY translation table with state-of-the-art linear motors, a vertical translation stage (Z) for focusing, and a vacuum chuck for holding the samples. The chuck includes a couple of planar orthogonal mirrors, which are part of the interferometric positioning system if installed.

The unit also allocates the writing laser and the interferometer laser. A Gallium Nitride diode laser (~ 405 nm) or a Helium-Cadmium gas laser (= 325 nm) is used for writing. The interferometer (optional) uses a 663 nm *Zeeman-split* Helium-Neon source.

The GaN laser has a typical useful life of more than 8000 hours. During such period, the write power level is kept constant by an electronic stabilizer. No forced cooling is required for this source.

The He-Cd laser tube has a typical useful life of about 4000 hours. During such period, its power level decreases monotonically. The initial high power level of the laser and the automatic control system for the laser beam energy compensate such decrease. This allows the use of the laser tube for most of its life. The laser is cooled by forced air. To this purpose, a duct connects the laser head to a fan, which is kept remote in order to minimize the vibration it could induce on the system.

Warning: make sure that the He-Cd cooling air exit is never wholly or partially obstructed.

Control unit

This unit is composed of a rack cabinet including most of the electronic subsystems that drive the writing unit. From bottom to top, the unit allocates:

- Uninterruptible power supply (UPS).
- XYZ motion controller (LW2).
- Main control unit, containing the supervising computer (LWØ) and the write control unit (LW1).
- Beam modulator driver (He-Cd laser only).
- Laser power supply (He-Cd laser only).
- Interferometer power supply (if installed).

LWØ is connected to a LCD display, a mouse, a keyboard, and an ethernet network. It is also connected to LW2. LW0 and LW1 include also all the connection to the writing unit and the interferometer, as described ahead.

Maintenance and cleaning

If the system is used by qualified personnel, maintenance is limited to occasional cleaning of its units. No greasing of the XY translation stages is required.

Cleaning should be included in the routine operations for the maintenance of every system used in clean-room. Its purpose is to minimize the *cross-contamination* and particle diffusion.

The work chamber, within operator's reach, must be kept perfectly clean and without contamination. If standard *clean-room etiquette* is followed for substrate loading/unloading, then cleaning operations will be very infrequent. For this purpose, powder-free gloves or properly shaped tweezers are required for substrate loading/unloading.

WARNING: use only appropriate clean-room gloves (i.e. not cloth gloves), talc-free type.

The substrate holder plate is the part most subjected to contamination. When necessary, its upper part can be removed and cleaned with a lint-free synthetic tissue (such as a *wiper* for clean-room) lightly wet with a solvent (ethyl, isopropyl or methyl alcohol, acetone). Maximum care must be taken to not touching or damaging the interferometer mirrors (if installed) when putting back in place the cleaned plate.

WARNING: Never clean mirrors and interferometer components.

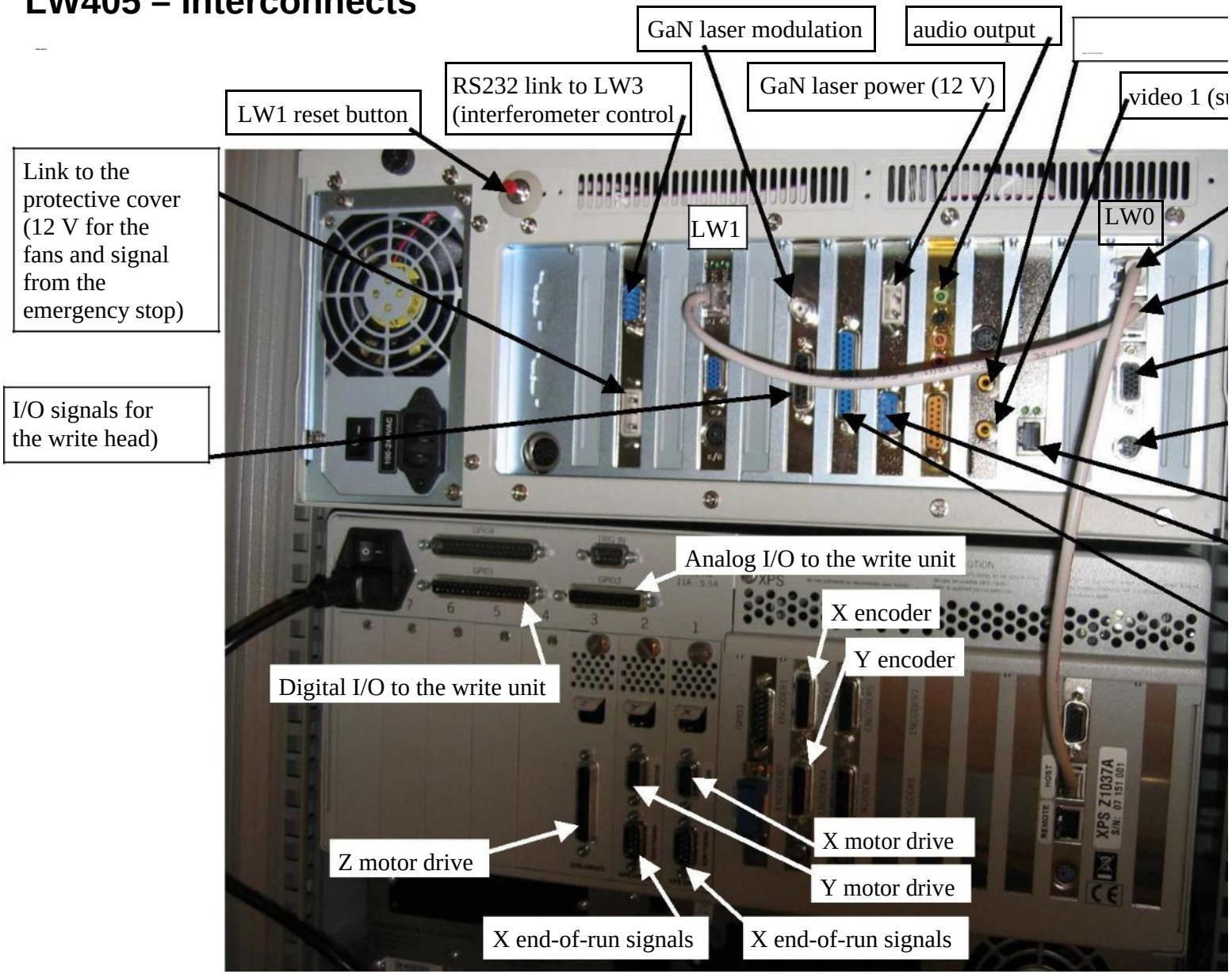
The different parts of the system console (keyboard, mouse, display) can be easily cleaned with a wet cloth. **Only for the keyboard** a cloth wet with ethyl or methyl alcohol can be used. **Never use organic solvents** for cleaning the display.

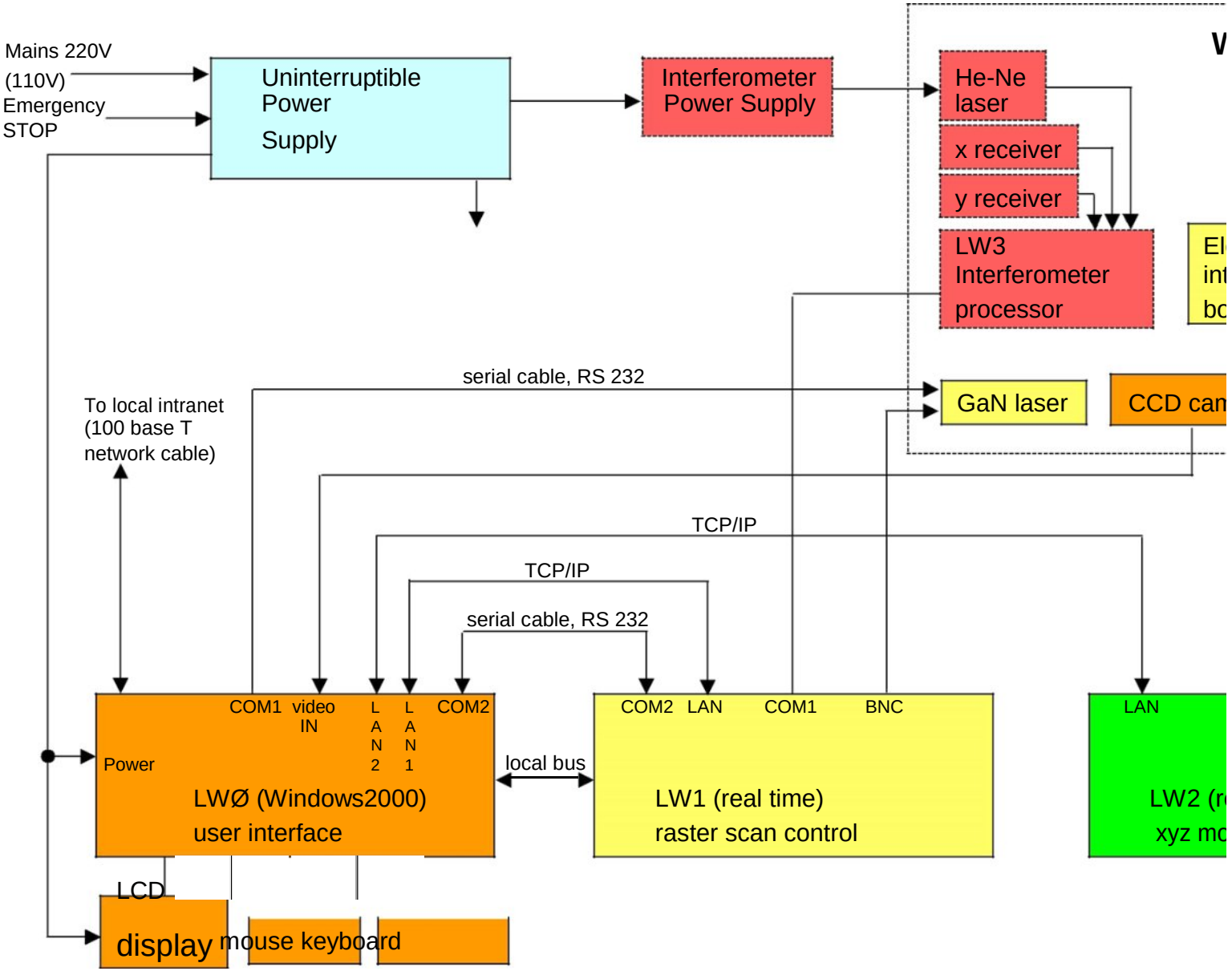
Uninterruptible power supply (UPS)

A compact UPS allocated on the bottom of the control unit, keeps the whole LW system ON during short electric energy interruptions. With the write laser ON, its autonomy is around 15 minutes. To start the uninterruptible power supply (and consequently the whole system), push the <1> button on its front panel.

To switch OFF the UPS and the whole system, push the red emergency button or the <0> button on the front panel of the UPS.

LW405 – Interconnects




Mains 220V
(110V)
Emergency
STOP
Uninterruptible
Power
Supply
Interferometer
Power Supply
He-Ne
laser
x receiver
y receiver
LW3
Interferometer
processor
serial cable, RS 232
GaN laser
To local intranet
(100 base T
network cable)
TCP/IP
TCP/IP
serial cable, RS 232
COM1
video
IN
LAN2
LAN1
COM2
Power
LWØ (Windows2000)
user interface
local bus
COM2
LAN
COM1
BNC
LW1 (real time)
raster scan control
LAN
LCD
display
mouse
keyboard

LaserDraw

release 6.2 (2007)

The LaserDraw software package, LD from now on, includes a set of programs for the control of the LaserWriter. LD has a modular and expandable structure. It allocates standard control procedures as well as *custom* procedures for specific user needs. Some of its components are used to control the micro-translator movements and the other electro-mechanic or electro-optical components allocated in the system. Other procedures are used only for processing the pattern data, and are not directly connected with the system operation.

A feature common to all LD procedures is their simple and intuitive use. To activate a procedure, the related *button* must be pressed. In this manual the words *key* or *button* are meant respectively as the real key of the keyboard and as the virtual button that can be pointed and clicked with the mouse on the displayed window. Some of the virtual buttons on the display can also be activated with the keyboard, pushing the symbol indicated on the button or typing the underlined character while keeping the <ALT> key down. When necessary, to prevent the operator from accidentally activate a command with the keyboard, the button can be activated only with the mouse.

The LD software package is distributed in the four computers that control the LaserWriter system: LW0, LW1, LW2, LW3 (if the interferometer is installed). LWØ operates on the pattern data and hosts the user interface. LW1 and LW2 control the writing process in real time, LW3 controls the interferometer. The operator can directly access only LWØ, where the classic WindowsXP* operating system is installed as the user interface with the system.

The data flow from design to pattern includes the following steps:

1. project, developed by the user on LWØ or other CAD workstation;
2. import of the project in the LaserDraw database operating in LWØ;
3. data processing in LW0 and transmission of the pattern to LW1;
4. write process, controlled in real time by LW1, LW2 and LW3, and monitored by the operator through LW0.

If the project is developed on a workstation other than LWØ, the data transfer to LWØ can be done through a floppy disk, a USB memory stick or a network connection.

The LaserDraw installation on LWØ uses two folders: C:\LW405 and C:\ARCHIVE. LW405 allocates the system drive programs and the database manager, while ARCHIVE allocates the data related to the patterns to draw. Note that the ARCHIVE folder is divided into 10 subfolders, ARCH_1 to ARCH_10. This structure allows different

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* WindowsXP is a trademark of Microsoft Corporation.

users to place their data in different archives. It also allows the storage of different pattern types in separate folders.

Main menu

After starting LD, a **main menu** is shown to the user, so that he/she can choose from the several possible options.

Job selection frame:

Data management This open the *Data Management* menu, that includes several possible options, all used for editing and processing the pattern data.

Make LDF This button opens a small window for the data conversion from the standard CIF format to the LDF machine-format.

System control frame

XY int. and **Z init.** for initializing the XY and Z microtranslation stages on system startup.

Start for the full manual or automatic control of the different components of the writing system.

Setup table to enter a template containing all system configuration parameters.

Cal. to enter a calibration template.

Exit End of the LaserDraw session.

Patterning mode frame

Three write options can be selected:
- the normal *beam raster scan*.
- the special *stage raster scan*
- *vector.*

Use and application of the different modes are explained ahead.

Usually, *Data management* is selected first. In this menu, *Import* is a relevant option. It must be performed either if the file with the data was generated on a remote workstation,

or if the file was generated locally in LWØ. The *import* phase is aimed at classifying the file that allocates the data (clearly, univocally and supported by informations) inside the database allocated in LWØ. In this phase the job related to the imported data is given a progressive number.

The *import* operation is just one example of the possible actions on the patterning data. Another typical operation is the selection of a job from the database, for making it an *active job.*. All possible actions included in the *data management* procedure and activated by the corresponding button are explained below.
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Data management

Each different job is associated to a database record and to a file that allocates the patterns to be written. The database record contains the following data:
- **title** assigned to the job, for its fast identification;
- **author**, name of the pattern designer;
- **notes**, utility annotations;
- **path**, indication of the folder where the data file is placed;
- **identification number** of file (ID#), corresponding to the data file name on disk.
- **date** of creation of the database record.

Each job can correspond to only one file that contains writing process data, or to a group of files. In fact, for a same job the *pattern* data could have been defined with several formats, after translation operations. In order to start a job, the data must be in the standard format accepted by the LASERWRITER, as described further on. Data in this format can be generated with a text editor or as the output from a graphic editor, or by translation from other formats.

The LASERWRITER does not use the design data format directly. Whichever the original format is, LWØ converts it to a proprietary format named LDF (Laser Draw Format), that keeps into account the distinctive features of the laser writing process. This is discussed in more detail later on. The LDF file contains all information for LaserWriter operation, and the operator is automatically driven to the possible patterning options for the specific layout of choice.

Two types of pattern data files can be converted to LDF and used for patterning: **CIF and DAT**. Other formats but must be previously converted into CIF or DAT. The list below shows the different situations that can originate CIF or DAT files.

1. **Standard CIF files**. This format (Caltech Intermediate Format), is described in details in the CIF section of this manual. It is typically used for microelectronic and microwave circuits. These may be obtained directly in CIF format through a layout editor (such as the *CleWin* editor included in the LaserDraw package) or created in other formats (GDSII, Gerber, etc.) and converted to CIF. Typically, the conversion is made by *CleWin*, through its *save as…* options.

2. **CIF files obtained from scanned bitmap black and white images**. This possibility concerns the generation of patterns through a graphic editor with bitmap output format. The *CleWin Bitmap to CIF* utility is capable to scan the black and white bitmap image from top to bottom and derive a standard CIF file from it.

3. **DAT files obtained from user's programs**. This Microtech proprietary format is described in details in the specific section of this manual. It allows the generation of patterns for diffractive optics and similar applications.

4. **DAT files obtained directly from bitmap grey level images**. This allows the user to create surface profiles described as grey levels of any 2-D image stored as a standard Windows bitmap file. The conversion from bitmap to DAT format is made automatically when the user imports the bitmap file into the database, as explained in the *Import* section.

CleWin

The Clewin frame in the *Data management* menu contains 4 buttons, for accessing the corresponding Clewin programs: Layout editor, Layout viewer, Bitmap to CIF and Area Calculator. Full details on the use of such programs can be found in the Clewin manual and its on-line help.

Layout editor

This is the main CleWin program. It can be used for microelectronic pattern design, as well as for patterns whose style is close to that used in microelectronics. Its output file has the standard CIF format, although other format can be handled as well. The CIF format is later used for creating the LDF format required by the LaserWriter.

Layout viewer

This procedure allows the operator to visually inspect the pattern, but with no editing possibility. This avoids accidental editing of the pattern during its inspection.

Bitmap to CIF

When a graphically complex pattern must be imported, typically in applications other than microelectronics, the designer may want to use a Windows Bitmap source file (black and white) . This could have been obtained with specific graphic editors, such as PowerPoint, Photoshop, Paint, etc. The *Bitmap to CIF* utility scans the image horizontally and converts the bitmap into a CIF file. Once converted, the data file can be edited and modified through the CleWin *Layout editor*. This allows the user to make a complex patterns as a bitmap file and then add other features through a CIF editor.

Area calculator

This utility simply computes the area of a CIF layout, or part of it.

Job database

This frame includes the procedures that operate directly on the pattern database.

Import

With the *Import* procedure, all data related to a single pattern is organized and classified in the database.

Only **CIF**, **DAT**, **BMP** formats are allowed for import. CIF files are typically created by the CleWin layout editor. DAT files are generated by specific user programs, BMP files result from image editors.

After the path and the name of the file to import is defined, the user is requested to insert the information that allows a future fast identification of the data. The pattern data and the information entered by the operator make up a perfectly defined ***job*** in the database. Among the requested information, the **title** of the job cannot be omitted, while the **author** and the **notes** are optional. The research path of the pattern data can be selected among the 10 available folders (ARCH_1…….ARCH_10) in ARCHIVE. The job ID# is assigned automatically, as well as the creation date of the database record.

The identification number is progressive and can never be assigned or modified by the operator. By eliminating a job from the database (see the *Delete* procedure), the ID number is lost and it cannot be used for other jobs. This procedure prevents the operator from making mistakes in the job classification.

The ID# is unique across the different folders in the ARCHIVE. In a typical R&D environment, the folders will be used by different classes of operators. But no two same ID# will be allowed, in order to make each job univocally traceable whichever folder it belongs to. It is good practice to use the ID# for marking all the accessories related to the process associated to that job, such as masks, containers, laboratory notes and so on.

The *import* procedure must be used also for grey level bitmap files. In this case, after clicking the *Select*, another small form is opened, asking the operator to enter other necessary information non originally included in the bitmap file, such as the pattern position and the actual pixel size.

Select

The *Select* procedure has a template with two windows. The higher window allows the selection of the archive to be used, among the 10 available. The lower window shows the content of the selected archive.

The job to activate can be chosen from the table and confirmed by pushing the *Select* button and going back to the main menu. Before confirming the selection, it is possible to know which formats allocate the data related to the *job* to activate.

The name of the selected job appears on the *active job* field of the main menu. The *Modify* and *Delete* functions are now useable, while before they were inhibited because of a definition defect of the *active job* to operate on.

If the writing data related to the *active job*, are already available (that is, already converted) in the LDF format, then the *View* procedure is active too. The presence of a specific file format (CIF, DAT, BMP) and/or the LDF format enables the corresponding editing function.

Modify

After activating a job, its database data can be modified with the *Modify* procedure. All fields can be modified, except for the job identification number.

Delete

Referring to the *active job*, with this procedure a data file and its related database record can be eliminated from the archive. In any case, the operator is requested to confirm the deletion. The ID# associated with the deleted job is lost forever.

CIF utilities

The *CIF utilities* frame of the Data Management template menu contains the *Edit CIF*, *Edit LDF,* and *Export LDF* buttons. The first two buttons are related to the possibility to make text editing directly on the data file. Data in CIF format can be graphically inspected by calling the *Layout viewer*, in the CleWin frame. The *View LDF* is explained below with more details.

DAT utilities

This frame hosts the utilities related to the special DAT source data format, mostly used for the fabrication of diffractive optics and other computer generated surface profiles. This format uses two files, as explained later in this manual: a DAT file that contains the exposure level of each pixel, and a TXT file that host other pattern information associated with the DAT file. The *View DAT* procedure is used for visualizing a DAT pattern and zooming into its details. The *Edit TXT* button allows the operator to modify the support information associated with the selected DAT file. The EXE to DAT button is for future use.

Make LDF

This procedure belongs to the *Job selection* frame of the LaserDraw main menu, but is described here for completing the data management discussion. *Make LDF* translates all pattern data, related to the active job, from the CIF or DAT format to the specific LDF format used by the LASERWRITER. After the translation, a new file is created, with *LDF* extension. This file is created in the same sub-archive where the source file was placed before.

When creating the LDF file from a CIF file, the compressed and standard data file is expanded and translated into the system-specific format. To this purpose, the operator must specify the laser focusing lens that will be used at patterning time.

A *shrink* factor may be entered before starting the translation. However, this feature will be effective in the next release of LaserDraw. It has been introduced here only for future compatibility with the incoming release. The user defined shrink value (positive or negative) will allow to slightly reduce or enlarge each element of the pattern, according to specific requirements of the technologic process for which the pattern is made.

The translation from a DAT file does not require any input from the operator. All information for a successful translation is already contained in the associated TXT file.

The LDF file resulting from the conversion contains all information necessary for creating the pattern. In principle. All other source files could be deleted. The only reason for keeping them is related to the possibility of modifying a pattern with the layout editor and then update its related LDF file. Remember that any modification in the original CIF pattern requires a new LDF file. It is also possible to editing directly the LDF file, using a text editor (*Edit LDF*, in the *Data management* menu). However this should be attempted only by expert users.

Typical data flow for a microelectronic (binary) pattern

In LW0 or a remote computer

Creation of the source data file in GDS, DXF, CIF or other standard format.
A generic file name can be chosen by the operator at design time.

GDS/DXF TO CIF

If the file is not created directly in CIF format,
CleWin opens it in the original format and saves it in CIF format.

IMPORT CIF, DAT or BMP

Reading of source CIF file from a generic position (HD,
floppy, network, USB devices) and with generic name.

The IMPORT operation produces three events:

1) the source file is copied (identical) in one of the 10 available archives in the C:\ARCHIVE directory.

2) Its name changes and becomes an automatic progressive number, followed by the extension that indicates the format. For example: C:\ARCHIVE\ARCH_4\012.CIF

3) a record is added to the database, that is in the file C: \LW0\WF.MDB

SELECT

Selection of the *active* job to be used for next operations.
A job is identified only by its numeric code.
The job to be activated is searched in one of the ten available archives.
The name of the *active* job is written in the first record of
C:\LW0\ACTIVE.JOB
The active job is indicated with the complete path and the numeric code, without extension.
For example, the record contained in *ACTIVE .JOB* can be:
"*C:\ARCHIVE\ARCH_4\012"*

Make LDF

The LaserDraw (LDF) format is the internal LaserWriter format.
The LDF format is achieved by translation from the CIF format with the *Make LDF* utility. The LDF file has the same identification code of the original CIF source file, and *.LDF* extension.

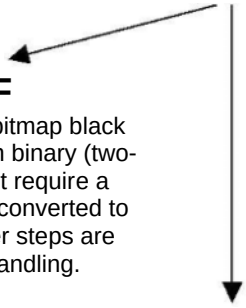
Selection of the write mode

Start of the write process

Typical data flow for a microoptic pattern

In LW0 or a remote computer

If the user developed the project using his/her own programs or other commercial packages (such as MathLab, SciLab, etc.), the source data will be produced in DAT format, with a support TXT file associated to it.
A generic name chosen by the operator at design time.
The name must be the same for both DAT and TXT file.
The extension must be *.DAT* fir the DAT file and *.TXT* for the TXT file.
If the project pattern is obtained from a bitmap file,
the user can save it with a generic name and BMP extension.
If the file contains grey level information, it is supposed to be patterned in multilevel mode.
Note that in this case the bitmap must be saved with no colors. Only grey levels are allowed.
If the file does not contain grey levels, i.e. it is a black and white image,
it can be patterned both in binary mode (after being converted into CIF)
or in multilevel mode (after being converted into DAT at import time).
Note that in this case the bitmap must be saved with no colors and no grays.



BMP TO CIF

This step is required only for bitmap black and white file to be patterned in binary (two-level) mode. DAT files do not require a translation to CIF. If the file is converted to CIF, using CleWin, the further steps are those related to CIF file handling.

IMPORT DAT or BMP

Reading of the source file in DAT+TXT or BMP format, from a generic
Position (HD, floppy, network) and with generic name.
The IMPORT operation produces four events:

1) the source file is copied (identical) in one of the 10 available archives in the C:\ARCHIVE directory.
2) Its name changes (it becomes a progressive number), and its extension that indicates the format.
3) the operator is requested to enter the pixel size and the position of the multilevel pattern. Such information is stored in a .TXT file, in the same archive as the DAT or BMP file.
For example: *C:\ARCHIVE\ARCH_4\012.DAT and C:\ARCHIVE\ARCH_4\012.TXT.*
4) a record is added to the database, that is in the file *C: \LW0\WF.MDB*

Note that is the file to import has BMP format, it is automatically converted into DAT.

SELECT

The job to be activated is searched in one of the ten available archives.
The name of the *active* job is written in the first record of *C:\LW0\ACTIVE.JOB*
The active job is indicated with the complete path and the numeric code, without extension.
For example, the record contained in *ACTIVE .JOB* can be: "*C:\ARCHIVE\ARCH_4\012"*

Make LDF

With the Make LDF utility all DAT file records are converted in the LDF record format, with the help of the information contained in the associated TXT file. The resulting LDF file has the same identification code as the DAT and TXT files.

Selection of the write mode

Start of the write process

START

The start template has two separate areas, surrounded by a blue frame. The left area is the ***manual* operation** area, the right part is devoted to automatic ***patterning*** process. The two sections are described below. Note that before starting an automatic *patterning* process, the operator must always transit through the *manual* area, at least for preliminary focusing of the substrate.

***Manual* operation**

With the *Manual* procedure, the operator has direct access to the electro-optical and electro-mechanic subsystems contained in the LaserWriter. *Manual* allows the accomplishment of dimensional measurements and verifications on the substrate, the definition of the focusing plane for the writing process and the choice of the laser focusing lens, according to the selected resolution. The functions associated to each frame and the related buttons are explained below.

Position

The upper displays of the *position* frame (with red numbers on a black background) show the XYZ mechanical positions as indicated by the optical linear encoders inside the translation stages. The lower displays (only for X and Y) show the absolute position indicated by the interferometric measurement system (if installed). All coordinates are displayed in micron.

The **reset** button initializes the interferometer electronics and forces the interferometric reading to 0. Note that the interferometric system needs about 5 minutes to start. During this period, 4 red dots are shown in the left side of each display, and the interferometer displays shows “no lock”. After warm-up, the red dots are green and the interferometer can be reset. After resetting, the position displays indicates 0,0. Note that **reset** must be made with the XY mechanical positions at 0,0. Otherwise, a position mismatch between mechanics and interferometer occurs. A message appears if reset is attempted with the XY stages in 0,0 position.

By clicking the **ref.** key, either the interferometric or the mechanic position is selected as the reference for manual distance measurements, as explained below. The selected XY display will present red numbers brighter then those not selected. Every time the **ref.** button is pressed, the reference is switched between the two position displays. After choosing the indication to use (mechanic or interferometric) for manual distance measurements, it is useful to press the **Ø** button, that zeros the reference display and sets a green color for the numbers. At this point, moving the substrate with the keyboard

keys (← – → ↓) for the X and Y axis and with **Pag–** and **Pag↓** for the Z axis, the position will be shown relative to the point for which the indicators have been zeroed. To exit this mode, press the **ref.** button again.

Go to

The ***Go to*** command group is made of 8 buttons that allow the direct reach of a pre-defined position.

With the **M1** , **M2** , **M3** buttons, the substrate translation system moves until it reaches one of the three memorized focusing points. This possibility is useful for defining the focus plane, as explained below. In fact, if the coordinates of the points that define the surface focusing are not modified, when a new substrate is inserted, the M command allows a fast positioning in the three points.

With the **A** and **B** buttons the position of two mark points can be reached. The use of the mark points is explained in detail in the “alignment on mark section”.

With the **0,0** command, the origin of the co-ordinate system is reached, that is the 0,0 position.

By pushing the **set** button, the substrate is positioned according to the coordinates indicated in the *set x* and *set y* fields. The content of these two field can be set to any position within the available run of the XY stages.

In the **xy step** and **z step** fields the operator can enter the amount of movement of the stages for each click of the ← – → ↓ **Pag**– **Pag↓** keyboard keys. The speed for XY movements can be set with the **slow-mid.-fast** buttons. The value of the **slow** and **mid.** speed can also be entered in the **xy speed** fields.

By clicking the **L** button it is possible to make L-shaped paths when moving the Y stage manually. The length of the short movement in X direction, at the end on the Y movement, can be set in the related field.

The **track** flag enables dynamic autofocus with “rings” while a *Go to* command is executed.

Note that two small graphic windows, in the lower right part of the video window area, show the positions respectively the xy stage position and the vertical Z position, within the end-of-run limits of the translation system.

Marks

This frame, with the related couple of **A** and **B** buttons (selectable only with the mouse) allows the definition of the coordinates of possible reference *marks* to use for writing on previously made patterns:
a) After substrate focusing, the substrate is moved to the first of the two *marks* and it is focused with precision.
b) The laser beam is sent on the substrate. The beam intensity level must be set to the minimum possible to produce some substrate (photoresist) luminescence. To this purpose, maximum video contrast and reduced sample illumination should be used.
c) With small substrate movements, the *laser spot* is precisely positioned on the mark (A) and soon switched off.
d) After clicking the **A** button, related to the x co-ordinate, the operator enters the x position that was assigned to the first mark at design time.
e) After clicking the **A** button related to the y co-ordinate, the operator enters the y position as well.
f) Steps a) to e) are repeated for the second mark.
At this point the design coordinates and the real ones are memorized, and can be used during the writing process, if the operator decides to use the marks. From now on the operator must not operate on the substrate holder as well as on the focusing lenses or the **A** or **B** buttons, otherwise the mark positions may be changed.

Lens

This frame shows the number of the lens currently set as the final beam focusing element. If the system hardware includes a sliding holder for the lenses, the lens position is sensed automatically and displayed as a clicked button. For systems with manual lens change system, the operator must click the proper button in order to tell the system which lens is currently installed.

Always pay attention to the distance between the lens and the substrate, avoiding their contact. The minimum distance between the substrate and the tip of the lens is about 1 mm, with lens #5.

With the **set z** button the substrate can be automatically moved vertically in order to reach a near-focus position for the selected lens. To this purpose, before clicking the button, the operator must enter the substrate thickness (in m) in the **substr.** field.

Focus plane

The *focus plane* group sets the coordinates of three points that define the focusing plane for the writing process. This group has three buttons (**M1** , **M2** , **M3**) to memorize the positions of three points that define the substrate plane, according to the following procedure:

a) after substrate loading, this is positioned on the first of the three points, properly chosen on its surface. Then the laser focusing lens is selected,

starting from lens #2. Hence, focalization is provided using the manual or automatic procedure, as described further on;

b) the XY position and the Z height of the focusing point are memorized by pushing the M1 key;

c) the procedure is repeated for other two points, respectively using the M2 and the M3 keys. Of course, these other two point should be millimeters or centimeters apart from M1, in order to achieve a precise plane definition.

Video

The *video* window includes 4 sliders. **Brightness** regulates the image brightness, **contrast** acts on the image contrast, and **light** sets the intensity of the red light that illuminates the substrate. Note that the **light** regulation can also be made by clicking the +/- rightmost keys of the keyboard. The **focus rings** slider sets the brightness of the series of rings projected on the substrate, when *focus track* is used, as explained later on.

The set of *rulers* buttons (**UR1**, **UR1**, **yell.**, **mark**) enables and disables a series of video utility rulers that can be used for calibrations and measurements. Details on their use are given during the operator's training.

In the lower right corner of the video window, a small frame with two button allow to switch the video source between the CCD camera for substrate inspection (default) and a camera placed in the work chamber. This second camera can be used for monitoring stage, substrate and lens position.

It is also possible to capture a frame of the video image (**freeze**) and save it in a file.

Focus (rings) and ***Focus (knife edge)***

Details on the use of the commands inside these frames are described in the *Focusing System* section.

Beam control

An on/off **gate** button and an on/off **shutter** button enable respectively an electronic control gate and an electromechanical shutter for the laser beam. Only if both are ON the slider settings can produce an output laser beam.

In this frame, the status of the beam scanner is shown, as a green (running) or red (stop) window. Two ON/OFF buttons allow the operator to intentionally stop or run the scanner. A *cal.* button opens a pink scanner calibration window. The buttons and sliders in this new window allow the operator to test and calibrate the beam scanning system. Details on this procedure are part of the operator training and are not discussed here.

Filter

In this frame the operator can set a coarse attenuation value for the laser beam. The optical transmission of the selected filter is indicated.

Substrate

The **UNLOAD** button moves the vacuum chuck toward the operator. The **LOAD** button brings the chuck back to its original position.

Patterning

For entering the automatic patterning procedure, the **>** button must be clicked. This enables all commands and buttons on the right section of the START window, while disabling most commands of the *manual* section. The pattern to write on the substrate is shown in the upper window.

If the active job corresponds to a two-level pattern, all necessary internal system settings for *binary patterning* are automatically activated. If the job corresponds to a multilevel pattern, all settings are make as well.

Before discussing the different options of the *patterning* section, a relevant point should be stressed here, related to the different write modes that the operator can select. This selection is made at main menu level, before calling the **START** procedure. But the result of the selection is used here, at patterning time.

Raster scan mode

This is the standard patterning mode. The whole pattern is divided into y-oriented strips placed side by side. The laser beam writes each strip by scanning the substrate in X direction, while this moves in Y direction.

Vector mode

The pattern is made by simply moving the XY stage under a still laser beam, following the data in the source CIF/LDF file. Note that in this mode the pattern can be made only of “wires”, as other geometries are meaningless. If other geometries are included in the original CIF file, they are simply ignored.

Stage scan mode

This mode allows high exposure levels on any substrate. Instead of scanning the beam along the surface, for strip writing, the beam is kept stationary and the substrate is moved in order to scan its surface left to right and right to left. After each scan line, the substrate is slightly shifted in Y direction. This results is writing the desired pattern by raster scanning. As the scan speed can be regulated by setting the X motor speed, any exposure level can be set: The slower the speed the higher the energy deposited per surface unit.

Having clarified the different use of each write mode, the role of each frame in the binary procedure can be described. Additional details are given during the operator’s training.

Graphic window

The pattern to write is shown in this window, according to the LDF file. In this window the operator is able to follow in real time the progress of patterning: the original image initially shown here is progressively covered with blue lines, according with the movements of the stage and the scanning path of the laser beam.

Centre position

Centre of the graphic window. This centre is automatically set in order to achieve the best image in the window.

Size

This field indicates the width and the height of a square that includes the whole pattern, that is the size of the graphic window.

Strips

The number of strips that will make up the whole pattern. This number is inversely proportional to the strip width, and depends on the lens selected for patterning:

Strip width

The nominal width of each strip, according to the magnification of the focusing lens:

Lens #2:	800 m
Lens #3:	400 m
Lens #4:	200 m
Lens #5:	100 m

Lens

The current laser focusing lens, as previously selected by the operator.

Current layer

The layer of the active job. This can be selected among the different layers defined at design time.

Options

In this frame the operator can select the number of patterning options. **Mirror X** and **Mirror Y** respectively mirror horizontally or vertically the pattern. This is useful when patterning masks for contact or projection exposure.

Use marks must be checked if the layer has to be scaled and rotated according to the A, B alignment marks set in the *manual* section.

Tone reverse makes positive patterns from the data of negative patterns and vice versa. Note that, for negative patterning, it is good practise to include a horizontal line above the pattern and another below it. This limits the area filling and greatly reduces the patterning time for reversed patterns.

Pause stops the system after each strip. Patterning restarts only when the operator clicks the *space* bar of the keyboard. This setting is useful when performing an exposure test, for changing the exposure level among different strips.

Interf. Is normally clicked if the interferometer is installed. It enables the use of the interferometer during the write process.

Set center to current position allows the allocations of the center of the pattern at the position currently indicated by the mechanical position displays. This feature avoid the relocation of an existing file in a different place by editing it, whenever its position in the substrate is changed. Simply reach the position to have as the center and select the option.

The **Pos. speed** field sets the XY stage speed for reaching the start point of each new strip. This can be normally set to to 5 mm/s for planar and horizontal substrates, if no autofocus is used or if the focus pane is used. For surface tracking with rings, 1 mm/s should not be exceeded, in order to comply with the processing speed of the autofocus system.

D-step sets the speed of the y stage while patterning. It can range from 1 to 10. The value 1 corresponds to the minimum Y speed (80 m/s) and the best pattern quality, with an "electronic" pixel 0.2 x 0.1 m. It is perfectly matched with the choice of lens #5. With a value of 2, each strip is patterned at a Y speed of 160 m/s, corresponding to an "electronic" pixel size of 0.2 x 0.2 m, for lens #5. Typical values for D-step are 2 to 4 with lens #5, 4 to 6 with lens #4, and 6 to 10 with lens #3.

Autofocus

Here the operator selects the focusing mode. If the substrate surface is very rough and structured, it may be convenient not to use any automatic focusing, and rely only on the initial manual focusing, with or without a "focus plane".

With **Track (rings)**, a set of rings is used for continuous focusing tracking. The best-focus condition corresponds to a preset diameter of the rings. Any vertical displacement of the substrate from the best- focus condition results in a diameter change. This is used for z correction. The use of this *Track* mode is recommended for high resolution patterning (lens no. 5 or 4) on smooth substrates.

The "Use plane" option enables the use of a focus plane, as defined by the M1, M2, M3, set in MANUAL. This options is the safest focusing option, because it is totally independent of the surface conditions of the substrate. It is recommended for any application where the substrate can be considered a good “plane”, despite its surface smoothness or roughness. It is the case of quality chrome or iron oxide masks or wafers, patterned at high resolution or rough surfaces (such as microwave substrates, thick plated surfaces, patterned at low resolution.

Multilevel pattern

This frame indicates the parameters of a multilevel bitmap file, if a multilevel pattern is being made.

Expo

The sliders in this frame set the exposure levels for the current job. For binary jobs, only **gain** should be used, setting the exposure level of each pixel of the pattern. Multilevel jobs require that **bias** is set too, for defining level of resist exposure corresponding to a black pixel of the bitmap file for the current job (the 0-level of the multilevel exposure).

Note that the proper exposure value depends on the D-step setting and the current lens selection (that is, the strip width), besides resist type and thickness. Approximately, the required exposure level is proportional to the D- step setting (that is, Y translation speed) and the strip width. For example, by changing the focusing lens from #5 to #4 the strip width doubles. Hence the exposure level must be doubled as well, in order to have the same amount of "photons/cm^2" as before. Also, by changing D-step from 2 to 4, the exposure level must be doubled, as the Y speed doubles. Otherwise, the number of "photons/cm^2" would be reduced by 50%.

GO

This command starts the pattern generation, using all options set by the operator. The graphic window showing the pattern to be realized is divided into strips. During the writing process, the graphic strips is progressively covered with blue lines. When the pattern is completed, the GO button becomes yellow, indicating that the pattern generation can be started again or just concluded.

Stop

This button interrupts the writing process. The GO button is turned to yellow and the operator can choose to exit the patterning procedure or to restart the process.

The x, y, z, strip#, line# and lock windows are used for monitoring the system operation while each strip is patterned. They indicate the amount of real-time correction of the position of the laser beam with respect to the substrate, in hundredth of micron, the current strip number, the current scan line and the status of the position feedback system that controls the Y stage movement.

SETUP

The **SETUP** procedure shows a table containing all configuration parameters of the system and their value. For details, please see to the section of the manual dedicated it.

CIF FORMAT SPECIFICATIONS

As mentioned before, CIF is the standard input format of the LaserDraw. The CIF denomination origin is related to a data format used in the electronic industries for the description of masks to be realized by photo-composition. CIF is the acronym for *Caltech Intermediate Format*, a simple data format developed at the California Institute of Technology. The following table indicates the commands provided, in the original CIF syntax[*]:

Command	**Meaning**	
L	*Layer*	masking level
W	*Wire*	connecting wire
B	*Box*	full rectangle
R	*Round*	full circle
P	*Polygon*	polygon path
DS	*Definition Start*	symbol definition starting
DF	*Definition Finish*	symbol definition end
C	*Call*	call of one symbol
DD	*Delete Definitions*	symbol cancellation
(...)	*Remarks*	any kind of note
E	*End*	end of CIF file

Except for the *End* and the *Remarks* commands, any other command is followed by a variable number of numeric or alphanumeric parameters.

In the case of *Wire, Box, Round, Polygon* "geometric" commands, the parameters are only numeric and indicate the pattern size to be written. For the "symbol" commands, the parameters indicate how to use each symbol.
All numeric parameters must be formed by integer numbers. The measurement unit used is **0.01 µm**. Therefore, a 1200 value for a geometric parameter indicates a quantity of 1200x0.01 µm, i.e. 12 µm.

The terminator of each command and its related parameters is indicated by a semicolon.

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[*] Carver Mead, Lynn Conway: Introduction to VLSI systems, Addison-Wesley, 1979

The coordinate system used in the CIF format reflects the normal conventions for the Cartesian coordinates: chosen an origin, the x axis is positive on the right side of the origin, and the y axis is positive above the origin. All this refers to the **real final position of the substrate patterns** and not considering what actually is on the mask, that could be mirrored with respect to the substrate.

Further on, the syntax of each command is described, with examples. The parameters are indicated by there meaning in small `courier` type. Among the parameters, spaces and small or big types can be inserted, and they will be ignored when the CIF records are read. The correct decoding of CIF commands is related to the **value** and the **proper sequence** of the integer numbers and characters that form the parameters. In the examples, possible alternative syntaxes (including the ignored types) are shown in parenthesis.

Layer: Preferential Syntax: **L** `level` **;**

Example: L NP; (Layer NP; LNP; Layer NP polysilicon)

First line of the mask level related to the polysilicon layer. All the following commands will be related to the patterns to realize in that specified layer, until a new *Layer* command is encountered. The initials of the level to refer to are defined arbitrarily by the operator. For example, the initials listed below are related to a typical nMOS process:

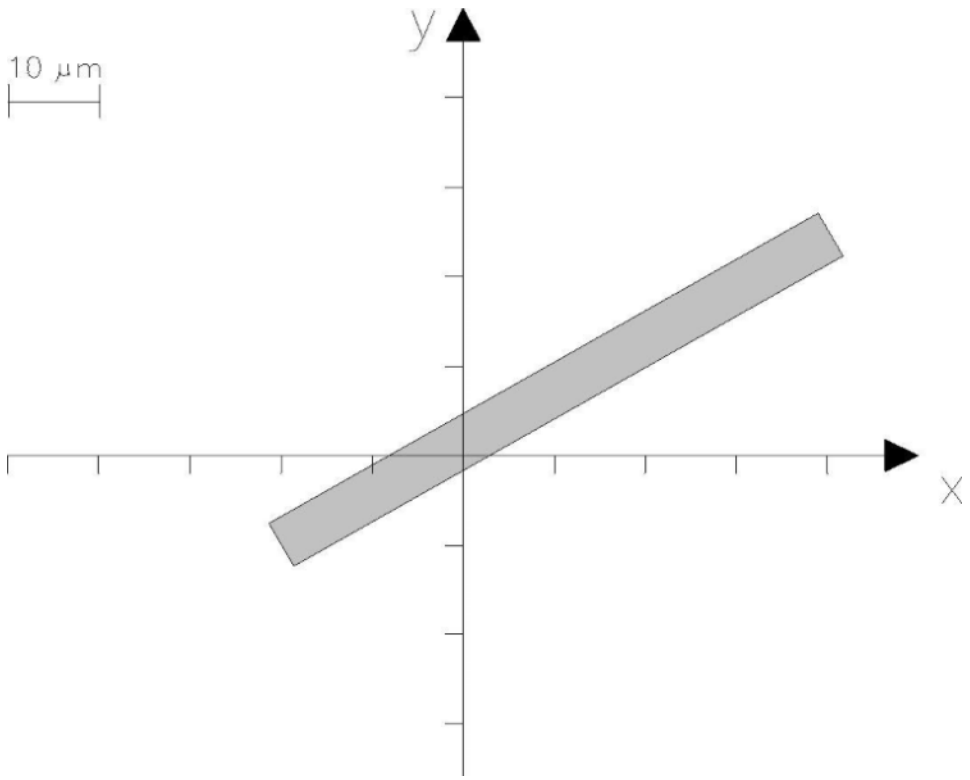
ND	diffusion
NP	polysilicon
NL	contact windows
NM	metal film
NI	ion implantation
NB	buried contacts
NL	windows in the passivation layer

Wire: **W** `width x1 y1 x2 y2 .... xn yn` **;**

Examples: W 1000 0 0 3000 2500
(Width = 1000 A 0,0 B 3000,2500)
Wire large 10 µm with beginning in the point with Cartesian co-ordinates x1= 0, y1=0 and end in the point x2=30 µm and y2=25 µm.

W 1000 0 0 3000 2500 1500 1500 0 1000;
Multiwire, large 10 µm beginning in point (0,0), passing through points (30 µm, 25 µm), (15 µm, 15 µm) and ending in (0, 10 µm).

W 600 -2000 -1000 4000 2500;
wire large 6 µm and placed according to the figure below:

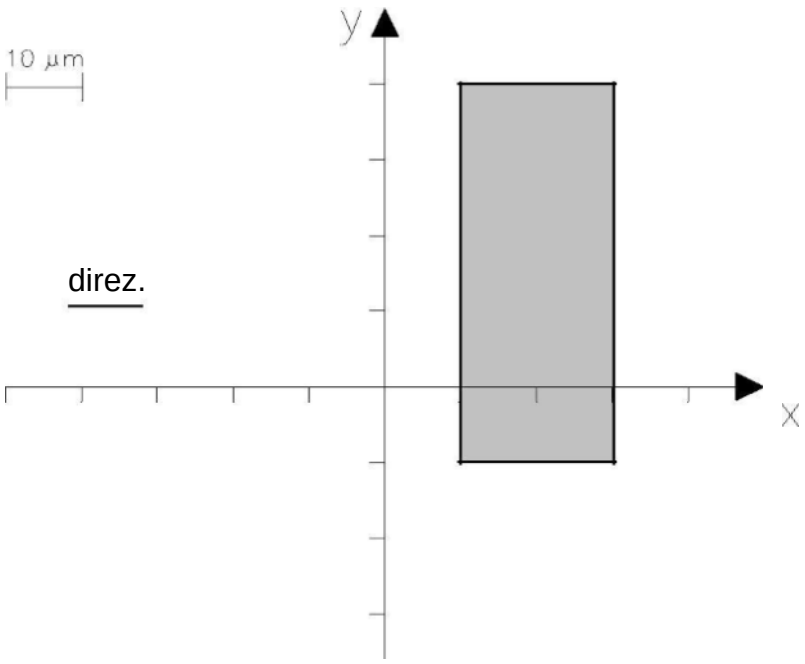


In this example, the wire starts and ends exactly in the specified points, without a pad. But usually the writing apparatus automatically inserts the pad at the end of the wire, that will result longer a half of its thickness, in each extremity.

BOX: **B** `length width xc yc xd yd` **;**

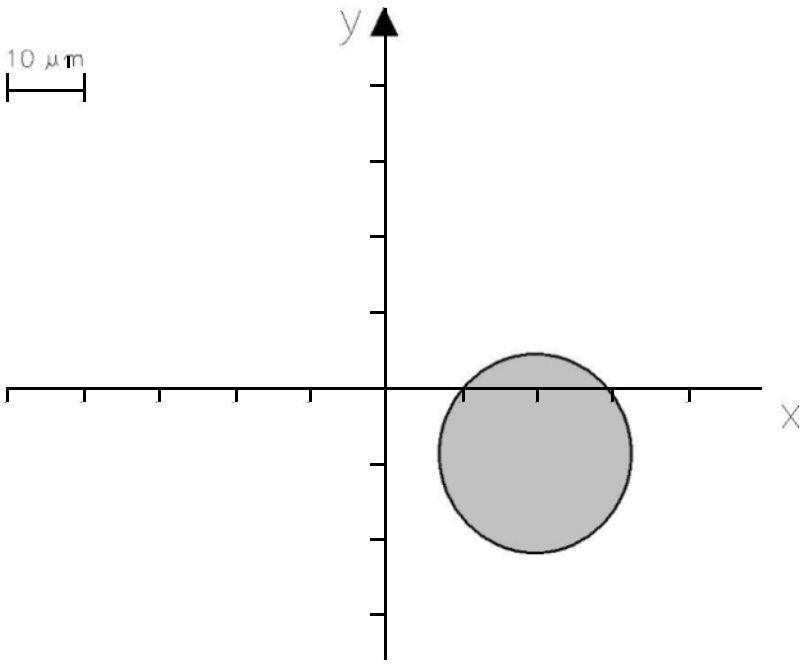
Examples: B 1000 2500 3000 2500 10 -5;
(Box Length 1000 Width 2500 Center 3000,2500
Direction 50, -25;)
Filled box, 10 µm long and 25 µm wide, centered in x=30 µm, y=25 µm. The direction is given by a vector parallel to the length, from 0, 0 to 50, -25 (or 10, -5 equivalently).

B 5000 2000 2000 1500;
in this case the rectangle is parallel to one of the axes and the parameters related to the direction are not considered, because not necessary.



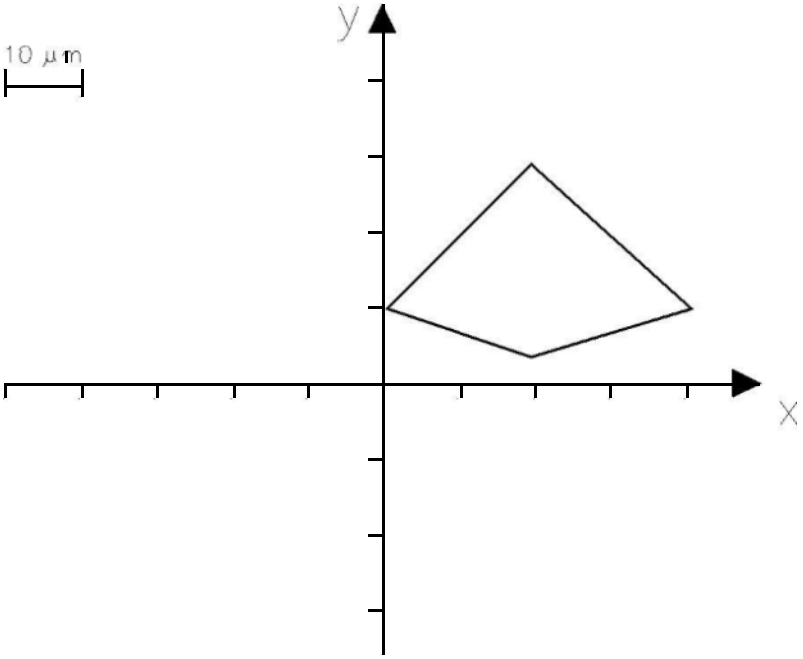
Round: **R** `diameter xc yc` **;**

Example: R 1500 2000 -1000; (Round pad Diam 1500 Center 2000, -1000;)
Circle with 15 µm diameter, with center in xc=20 µm and yc=-10µm.



Polygon: **P** `x1 y1 x2 y2 .... xn yn` **;**

Examples: P 0 1000 2000 3000 4000 1000 2000 400 ;
(Polygon A 0,1000 B 2000,3000 C 4000,1000 D 2000,400;)
Polygon with vertex (0, 10), (20,30), (40, 10), (20, 4).
It's implied that the last polygon side is defined by the first and the last vertex.



Polygons are supposed to be filled, with a Ø - thickness perimeter line.

Definition start **DS** n a b **;**

Examples: DS 6 100 1;
(Def start symbol # 6 Scale factor 100/1;)
Definition start of symbol number 6, described in the commands that follow. All the measurements that appear in such commands are to be multiplied by the factor 100/1.

DS7 2540 1
definition of symbol number 7. The parameters will be multiplied by 2540.

The previous examples show that after defining a symbol a scale factor is assigned for the commands related to the definition. In the first example a factor 100 is indicated. This means that the parameters related to the commands that form the symbol n. 6 still are to be multiplied by 100. This allows the use of 1 µm as a measurement unit for the parameters, instead of 0.01 µm. In other words, the CIF translator will multiply the parameter value, by the scale factor indicated in the DS command.

As well, in the second example the scale factor 2540 allows the use of *mils* and not centesimal of micron for the symbol definition.

Definition finish **DF;**

Example: DF; (Definition Finish;)
definition finish of a symbol.

The DF command must terminate the commands sequence that defines a symbol. The following example shows how a symbol with three wires is defined and how it will be "expanded" for the pattern generation, referring to the indications contained in the DS command.

Symbol definition:
DS 4 100 1; W 10 0 0 200 350; W 15 10 10 30 10; W 5 50 50 10 50; DF

Expansion:
W 1000 0 0 20000 35000; W 1500 1000 1000 3000 1000; W 500 5000 5000 1000 5000;

Call **C** `n list of_transformations` **;**

Example: C 6 T 100 0 MX R -1 2 ;
(Call Symbol # 6 Translated to 100, 0 Mirrored in X Rotated of -1,2).
Call of symbol number 6, previously defined. Three operation are done on this symbol:
- translation (T) of the origin of the symbol coordinates to the point x=100, y=0 (micron!). Note that the # 6 symbol is considered as like in the previous example, i.e. with "DS 6 100 1". This means that the assignment of the new origin already takes in account the scale factor 100/1;
- mirroring (M) in direction X. This means a sign change of all the X coordinates contained in the symbol;
- rotation (R) of the X axis of the symbol, with direction set by the vector that starts from the origin and has vertex in x=-1, y=2.

The possible transformations listed in the *Call* command are the following:

T `x y`	translation to the indicated point
MX	mirroring in x direction
MY	mirroring in y direction
R `x y`	rotation of the x axis to the direction defined by `x,y`.

It's important to note that **the transformations are read in sequence**. Hence, their succession in the command cannot be arbitrary. For example, the "C 6 T 100 0 MX R -1 2" command will produce results completely different from the "C 6 MX R -1 2 T 100 0" command. In fact, in the first case the translation is the first operation performed (or executed), while in the second case it is performed after mirroring and rotation.

In the CIF file **all symbols must be defined before being called.**

Delete Definitions **DD** n **;**

Example: DD 50; (Delete Definitions greater than or equal to 50;).
The command indicates to the CIF translator that the symbols with numbers ≥ 50 must not be considered for pattern generation.

The DD command is useful for the possibility that it offers in generating CIF files divided in several parts related to different projects, i.e. linking together several CIF files in a same file. For example, to create a mask containing 3 projects it is possible to produce, in the initial part of the file, a symbol "library" used by the three projects. The following parts of the file should contain only the specific symbols of the different projects, separated by the *Delete Definitions* command, according to the following example:

1) ...Definition of 30 common symbols...
2) ...Commands and definition of symbols of first project...
3) DD 31
4) ...Commands and definition of symbols of the second project...
5) DD 31
6) ... Commands and definition of symbols of the third project...

During interpretation, the previous sequence becomes:

1) Symbol creation, i.e. assignment of computer memory to each of them.
2) Patterning related to the first project, using symbols of the common library and specific symbols of the first project (that takes up memory).
3) Elimination of the specific symbols of the first project from the memory, except for those of library (30).
4) Patterning related to the second project, using symbols of the common library and specific symbols of the second project (that absorb memory).
5) Elimination of the specific symbols of the second project from the memory, except for those of library (30).
6) Patterning related to the third project, using symbols of the common library and specific symbols of the third project.

Remarks **(.....);**

Example: (Here starts the second project);
Annotation, recognized by the CIF interpreter because of the presence of parentheses.

Besides inserting annotations in the file, the parenthesis can be used to suppress the execution of one or more commands.

End **E**

The capital letter E indicates the end of the CIF file. It must be the last record of the file. It cannot be followed by another character, not even by ";".

The LDF format

The internal data format used by the Laserwriter for pattern generation is derived from CIF. It is named LDF (LaserDraw Format) and takes in account the specific characteristics of the writing unit. It is possible to get this format by the translation procedure <CIF to LDF>, according to the following steps:

- separation of commands placed on the same record, in single records for each command;
- removal of comment or empty records, and records related to user expansions;
- symbols extraction and scaling;
- file creation with symbols named and transformed according to the indications contained in the *Call* commands;
- file arrangement in a sequence of Layers;
- separation of multiple *wires* in single wires;
- conversion of patterns (box, round and polygon) in order to be generated only by *wires*;
- arrangement of the *wires* of each layer, in the sequence: horizontal *wire*, vertical *wire*, *wires* in other directions.

The syntax of the LDF file records is similar to the CIF syntax. There can be only two kinds of records, *layer* and *wire*:

L `level` **;**

Example: L NP
masking level start called NP

W `width x1 y1 x2 y2`

Example: W 1000 0 0 3000 2500
wire large 10 µm starting in the point with Cartesian coordinate in x1= 0, y1=0 and end in point x2=30 µm, y2=25µm.

In the LDF format each *box* is changed in *wire*. In this change it is necessary to take in account that in the starting CIF format, the *wire* has pads, i.e. it must be extended by W/2 at both ends. The box, instead, doesn't have pads and must not be extended. In the LDF format, the differentiation between a *wire* originated from a CIF *wire* and a *wire* originated from a box depends on the sign of W. A *wire* with positive thickness indicates its origin from a CIF *wire*, and it is automatically extended when patterning starts. A *wire* with negative thickness derives from a *box* and is not extended. Remember that the <step> function in the "**view**" procedure allows the analysis, both graphic and in the contents, of a single records of the selected LDF jobfile.

In order to compress the size of an LDF file, the CIF to LDF translator uses also some incremental commands for defining the patterns:

H `width  x1  y1  DeltaX`

V `width  x1  y1  DeltaY`

G `width  x1  y1  DeltaX  DeltaY`

Examples: H 3500 2000 150000 400
horizontal wire large 35 µm starting in the point x1= 20, y1=1500 and 4 µm long.

V 3500 2000 150000 400
vertical wire large 35 µm starting in the point x1= 20, y1=1500 and 4 µm long.

G 3500 2000 150000 400 5000
generic wire large 35 µm starting in the point x1= 20, y1=1500 and length given by SQR.(4^2 + 50^2) µm.

Polygons can be described by incremental commands, with "Q" as the identifier:

`Q  x1  y1  DeltaX2  DeltaY2  DeltaX3  DeltaY3 ……`

where each Delta is the distance from the first vertex.

Note that the LDF format, for its simple structure, is also suited for being generated by user created programs.

Database cleanup

The LaserWriter keeps all pattern files organized in an internal database with ten separate archives (arch_1 to arch_10). Each file, that is each “job”, is automatically given a unique numeric identifier, despite of the archive it belongs to. The numeric identifiers range from 001 to 999. Hence, the database cannot handle more that 999 jobs. This may seem a limitation, but actually it normally corresponds to several years of system operation. The reason for limiting to 999 the number of files that can be handled by the database is related to the concept of keeping in the system only files that could be of real interest, and not old and obsolete files that nobody would ever use again.

The note below is a guide for database cleanup, that is for removing all data from the database and keeping only useful files. This cleanup is made normally either if the maximum number of files has been reached (999) or just after system installation (to remove most of the files used only for testing the system).

The database pointers are contained in C:\LW405\Wf.mdb file. In order to cleanup the database, this file should be initialized. This action will remove all links with the existing data files in the archives, even if the files are still in the archives. If some files in archive are to be used again in the future, they must be saved in a separate folder and later imported again.

According to previous introduction, here is the complete safe sequence for database cleanup.

1) Start LW0 and explore the database (<Select> and <Layout viewer>, from the “Data management” menu), taking note of the ID code and the title of the files that should not be destroyed. Do not forget to explore all archives, not only “arch_1”.

2) Exit LW0.

3) Enter the C:\archive\temp folder and delete all files in this “temporary” folder.

4) Using the ID codes previously annotated, move the corresponding xxx.CIF files from the archive where they are to the “C:\archive\temp” folder. Note that only CIF files should be moved, for binary-type patterns. For grey-level pattern, only BMP files should be moved. All CIF and BMP files to save should be placed in the same “C:\archive\temp” folder, even if they came from different archives.

5) Enter arch_1, arch_2, etc… and delete all files remained in such archives. DO NOT delete the folders.

6) Enter the C:\LW405 folder

7) Make a copy of the “empty.mdb” file (by using copy and paste). A “Copy of empty.mdb” file will be created. This is just a precaution, in case the “empty.mdb” files is accidentally cancelled.

8) Delete the database pointer, that is delete “Wf.mdb”

9 Rename “empty.mdb” to “wf.mdb”. Now an empty database pointer has been created, corresponding to the empty archives.

10) Start LW0 and enter “Data management”.

11) <Import> the files previously saved in the “temp” folder, according to the normal import procedure. The ID number of such files will start automatically from 001. Remember to import the files into the proper archive, according to how you decided to use the different archives. For example, “arch_1” could be devoted to binary patterns only, and “arch_2” to multilevel patterns.

SETUP

The **SETUP** procedure shows a table containing all configuration parameters of the system and their value. This table is stored in the TABLE.DAT file in the LWØ directory. In normal conditions there is no need to directly set or modify the values in the table. For this reason, the access to SETUP should be limited to selected operators only, and totally denied to regular users. Hence, the information below, related to the use of each parameter, should be considered only informative.

The number on the left indicates the displayed field number, that is the number of the parameter..

1 **Not used**

2, 4, 6 **x, y, z mechanical positions.**
These indications are *mechanical*, meaning that they are the nominal positions of the stages, and may differ from the real coordinates - as indicated by the interferometer (if installed) - because of the mechanical tolerances of the translation stages. Note that the patterns are made according to the interferometer reading. Hence, the mechanical positions are to be considered just indicative of the real position. Note also that when the system is turned off, the mechanical position is stored, and restored when the system is turned on again.

3, 5 **x, y interferometric positions.**
Readings from the interferometer and reference positions for pattern generation. Note that the interferometer requires about 10 minutes for its stabilization after being turned on. When ready, however, its reading is a random number, until it is reset. This is accomplished automatically when entering the MANUAL procedure, where the interferometer reading is preset to the mechanical reading. Otherwise, if the operator enters the manual mode before stabilization, the interferometer display has a random reading. After stabilization, the operator can preset the interferometer reading to the mechanical reading by pressing the **=** button in MANUAL.

7 **reserved**

8, 9 **X, Y off-center** (for the next release of LaserDraw)**.**
The numbers in this field indicate an offset position that is reached after an *home search* performed on the XY stage. This offset is used both for reaching a position that is exactly the center of the stages (that is, for zeroing the small errors of the home sensors in the stages), or for intentionally setting a home position other the center of the stages.

10 **Measurement reference.**
Values 1 or 2 indicate respectively a reference set to the mechanical or to the interferometer reading, in MANUAL. The value can be set by the *ref* button in the MANUAL template. The use of a reference is related to the possibility of making measurements when using the LaserWriter for surface inspection. For measuring distances, the operator can temporarily set to Ø the xy display - by pressing the *0* button - with the substrate located in a position used as the Ø-reference. After making a measurement, the indication of the regular position is restored by pressing again the *ref.* button.

11, 12, 13 **x y z position of the M1 point**.
M1 is one of the 3 points that define a focus plane. This is the plane where the laser focus lies during the pattern generation. The possibility of setting a focus plane allows the operator to make a pattern even on tilted substrates.

14, 15, 16 **xyz position of the M2 point.**

17, 18, 19 **xyz position of the M3 point.**

20, 21 **Utility xy position.**
xy coordinates that can be stored with the *SET* button in MANUAL mode. Later, this position can be reached with the Goto SET button, in MANUAL.

22 **Reserved**

23, 25 **xy design coordinates of Mark A.**

24, 26 **xy actual position of Mark A.**

27, 29 **xy design coordinates of Mark B.**

28, 30 **xy actual position of Mark B.**
The actual xy positions of Marks A, B are defined during the *alignment on marks* procedure, in MANUAL. At patterning time, the information related to the mark positions indicated in the job data file and the information on the actual mark positions are used for rescaling and repositioning the current layer. This allows the layer to be aligned with other layers already existing on

the substrate. Typically, after patterning a layer the substrate is removed from the vacuum chuck, for resist development and surface processing. Later, it can be back in the LASERWRITER for patterning another layer.
Even though the vacuum chuck has some reference metal stops for the substrate, a precise alignment is usually necessary. This is achieved by means of the alignment marks.

31,32 **Low/high speed.**
The value of the xy speed for manual movements set for the slow/medium buttons, in micron/s.

33 **XY acceleration.**
The preset acceleration value when a X or Y stage starts moving.

34 **Filter #.**
The number of the laser attenuator currently set.

35 **Shutter.**
A value 1 indicates that the shutter of the writing beam is on (the beam goes through it).

36 **Reserved.**

37 **Reserved**

38 **Current focusing lens** (2 to 5)**.**

39 **Sspeed**
X scanning speed in stage-scan mode.

40 **MaxSpeed**
The preset maximum speed for X and Y

41 **fast/slow xy speed.**
The default xy translation speed when the manual mode starts. It can be set fast (2), medium (1) or slow (0).

42, 43 **xy step, z step.**
The amount of x, y or z translation when pressing a manual movement key (arrows),

44 **Positioning speed.**
The speed (mm/s) used for repositioning the Y stage from the current positions to the start point of the pattern, or from the bottom of a strip to the top.

45 **Wvc - wavelength compensation.**
When the interferometer in installed, this factor compensates the interferometer reading for the air refractive index.

46 **Light level.**
This value corresponds to the level of the red source used for substrate illumination.

47, 48 **Brightness and contrast.**
Settings for the video window.

49, 50 **KnifeX1, KnifeX2.**
These values respectively set the x position of the left and right side of a yellow frame in the video window, surrounding the area used for autofocus, when the knife edge is used.

51,52,53 **Reserved.**

54 **Reserved** (Z shift).

55, 56, 57 **A, B, C coefficients.**
These 3 parameters define the plane of the substrate. The values stored in the table filed are respectively multiplied by 10^{12}, 10^{12}, 10^{8}.

58 **Reserved.**

59 **Focus plane.**
Status of the focus plane:
- 0 - undefined.
- 1 - defined by M1, M2, M3 and A, B, C.

60 **Reserved.**

61, 62 **Mirror x, mirror y.**
Sets (1), resets (0) pattern mirroring respectively in x and y direction.

63 **Focus mode**
Current focus mode:
- 0 - none.
- 1 - focus plane.
- 2 - rings.

64 **Tone reverse.**
A value 1 indicates that reverse mode is set. Patterning is made by illuminating everywhere but the pattern areas. In order to limit the written area in the substrate, it is recommended to put, at design time, a straight line above and below the original pattern.

65 **Use marks.**
This field is set to 1 when the operator wants to use the marks (A, B) for aligning two or more layers.

66 **Write mode.**
The laser writer operates normally in beam scan mode (0). For specific tasks, the mode can be set to vector mode (1) or stage scan mode (2), with the scanner is switched off and the pattern obtained by keeping the laser beam still and moving the substrate.

67 **Shrink** (for future use)**.**
This shrink factor can be set at pattern time, in hundredth of micron. A positive shrink squeezes all geometries, a negative value blows them up.

68, 69 **Size X, Size Y.**
The width and height of a rectangular area that encloses the pattern.

70, 71 **X Centre, Y Centre.**
The x, y position of the center of the rectangular area that encloses the pattern (see 68, 69).

72 **N records.**
The total number of records in the LDF file.

73 **Strips-lines.**
The number of vertical strips that make up the pattern, in beam scan mode, or the number of horizontal lines, in stage scan mode.

74 **Current strip.**
The number of the strip currently being written.

75,76,77,78 **x min, x max, y min, y max.**
Position of the corners of the current strip.

79, 80 **Z speed, Z acceleration.**
Porameters for the Z stage.

81, 82, 83 **Stored light, brightness and contrast (LBC).**
LBC levels stored when pressing the STORE button in the “focus (knife edge) “ frame. These are the optimal levels to use when focusing with the knife-edge technique.

84 **Reserved.**

85 **D-step.**
The currently set d-step value for patterning.

86 **Ztrack.**
This parameter indicates if the user has set Z track with the focus rings.

87,88,89,90 **Box XA, YA, XB, YB.**
These values define the video area used for automatic focus track. The area can be selected or modified by the operator, according to specific needs or substrate characteristics.

91 to 96 **Settings for focus tracking.**
These fields contain, in a coded format and for each focusing lens, the video brightness and contrast, and the optimal ring brightness and diameter for video processing when using focus tracking with rings.

97 **Reserved**

98 **Password.**
Numeric code for accessing the system setup table.

99 **Reserved.**

100 **Backlash.**
A calibration parameter for the stage scan mode.

101 **Current matching-lens selection.**
This parameter indicated the number of the lens for which the system is compensating the achromaticity of the optical path at the laser wavelength.

102 to 105 **Match 2 3 4 5**
The position of an internal element that compensates the achromaticity of each focusing lens.

107,108,109 **Temperature, Pressure, Humidity**
The environmental parameters used by the interferometer for precisely evaluating XY movements, respectively in °C, mmHg, %.

110 **Reserved**

111…116 **Magnification of the focus lenses.**
The magnification of the final focusing lens is indicated here, respectively for lens positions 1 to 6. Only position 2, 3, 4, 5 are available for patterning. Position 1 is reserved for future developments and presently corresponds to "no lens". Position 6 is available for installing other lenses or accessories. The magnification indicated in the fields is multiplied by a factor of 1000. The magnification values are entered in the fields when the system is calibrated for the first time, and are obtained from test patterns. The best value for each lens corresponds to the minimum stitching error between adjacent strips.

117…122 **Position of the focus lenses.**
The position of lens holder is sensed by a transducer and its value is entered here when the system is calibrated. It is shown in the START template, together with the number of the corresponding lens. For systems with manual lens changer, a clicked button is shown when the lens holder is manually set in a right lens position, corresponding to one of the mechanical stops provided. For systems with motorized lens changer, positioning of a lens is made by clicking the corresponding button.

123…128 **Chuck height.**
For each focusing lens position (from #1 to #6), this field contains the z position value of the vacuum chuck for focusing, with a hypothetical Ø-thickness substrate. This setting is made at calibration time. It is used together with the field no. 174 (substrate thickness) for a fast setting of the focus position using the Goto z button.

129…136 **Filter 0…7**
The write unit contains a variable attenuator for the write beam, with 8 preset attenuation values (only 5 used) for coarse regulation of exposure energy (the fine regulation is made through direct laser modulation. These fields contain the positions of the attenuator that correspond 100%, 30%, 10%, 3%, 1% transmission values.

137,138 **Reserved**

139 **Filter delay.**
This parameter sets the speed of the variable attenuator.

140, 141 **X shift, Y shift** (for future use)**.**
Offset of the pattern, defined by LW0. The offset allows each pattern to be shifted from its original position - as defined in the data file - to a preset part of the substrate. It is used mainly for making exposure tests.

142, 143 **Delay SX, DX.**
Parameters for the optical alignment of the beam scanner.

144 **Y/X ratio.**
Value of the orthogonality error in the XY interferometer reading, for its automatic compensation.

145 **Reserved.**

146 **Sgn. delta**
Values -1, 0, +1 in this field set the sign (direction) of the correction of the laser beam position in x direction This is used at writing time, for correcting in real time the pattern position, under interferometric control.

147…152 **Spot obj 1...5.**

Values of the diameter of the laser beam focused on the substrate, for each lens. This value is entered at calibration time, and is used by the system for slightly shrinking all patterns in order to compensate for the geometrical error due to the finite spot size.

153…158 - **D-step 1…6.**

This parameter sets the speed of the y axis, while patterning, for each lens. Its value is a multiple of 0.1 m. The lower the value, the better the edge quality of the patterns. The higher the value, the faster the writing process is. For example, by using the lens no. 5 the size of the focused spot is about 0.8 m, which is also the width of each scan line. By setting D-step = 2, two subsequent scan lines result only 0.2 m apart. Hence, the scan lines overlap for 0.8 m, producing very high resolution in terms of edge roughness of the patterns. Considering that with the lens no. 5 the scan width is about 100 m and that 800 scans/s are made, the resulting patterning speed is 0.2 x 100 x 800 = 16000 m^2/s.

Buy setting D-step = 5, the scan lines are 5 • 0.1 = 0.5 m apart. A medium quality of edge roughness results, but the area coverage speed is increased by a factor of 2.5. When starting a new pattern, the operator can choose the proper D-step value.

159 **Dspeed.**

This parameter is used in the electronic loop for matching the speed of the Y stage with the frequency of the beam scanner, in beam scan mode.

160 to 165 **End-of-run.**

Positions of the x^+, x^-, y^+, y^-, z^+, z^- end-of-run, in hundredth of micron, referred to the central home position.

166, 167 **Max xy step and max z step.**

Check values for generating a warning message when the operator selects large manual movements, in MANUAL.

168 to 171 **Min bias, Max bias….**

Calibration parameters for the exposure system.

172 **Focus laser.**

Brightness of the focus rings used for focus track.

173 **Max substrate thickness.**

This number should never be changed from factory setting. It limits the maximum value the operator can enter when setting the substrate thickness.

174 **Substrate thickness.**

It refers to the substrate loaded in the system. When the operator sets this value the system can rapidly approach the focus position for the current lens. This is accomplished by pushing the Goto z button.

175 **Vacuum.**
This indicated the status of the vacuum line:
0 - no vacuum
1 - vacuum ok

176 **Reserved.**

177 **Pos. obj.**
Reading of the sensor for the position of the slider that holds the focusing lenses.

178 **mW x 10.**
Reading of the maximum power available from the laser source.

179 **Cabinet temperature.**
Reading of the cabinet temperature sensor (if provided).

180 **Reserved.**

MULTILEVEL DATA ORGANIZATION

Grey level patterning allows the localized modulation of resist thickness, according to the grey level of each pixel in a bitmap-like source data file. As multilevel processing is an application specific task, with several unconventional steps, here it is described separately from the standard two level (binary) processing.

The whole flow, from data preparation to laser writing is discussed. However, it must be pointed out that multilevel patterning is an absolutely non standard process, where operator experience has a role much more relevant than in binary processing.

Multilevel patterning is typically required for the fabrication of diffractive optical elements (DOE), micromechanical devices and other non-microelectronic devices. DOE fabrication is by far the most relevant application of grey level patterning. For this reason, the following discussion on data management will refer only to it.

A DOE is usually made of a two- dimensional pixel array, where each pixel is a *phase element* of the whole optics. The phase of each point of the wavefront transmitted or reflected by the DOE is delayed according to the phase contribution of each DOE pixel, that is the pixel optical thickness.

The variable relief of a DOE is usually made in a resist film, whose thickness is chosen according to the operating wavelength of the DOE. The film can be used directly or becomes the base for the fabrication of a shim for embossing the final DOE.

The thickness of each pixel in the resist is set by the photon dose used for exposing it. Hence, while the laser beam is moved along the resist surface for making the pattern, its intensity is modulated according to the instantaneous position of the beam.

A data file is used for instructing the pattern generator about the thickness of each pixel. Typically, it is generated by programs developed by the DOE designer or comes as an output file from one of the few commercially available specific CAD tools. Differently from microelectronics, where data descriptors are well defined and standard (GDSII, CIF, etc.), no universally recognized rule is still available for DOE data. For such reason, when MICROTECH added the grey level feature to the LaserWriter, a simple and easy to handle data format was adopted. In this way the designer can create a properly formatted input data file for the LaserWriter without complex data manipulation.

According to the binary patterning procedure, for multilevel patterning the LaserWriter requires a LDF input file. However, the structure of a LDF file for grey level patterning is quite different than that for binary patterning.

For generating the proper LDF file from the user data file (here indicated as *Userdata*), the **Data Management** procedure must i**mport** the following files from one of the available resources of the computer:

- *Userdata***. DAT**
- *Userdata***. TXT**
- *Userdata***. BMP**

The **.DAT** file must contain only the data related to each pixel, formatted according to the indications contained in the **.TXT** file. The **.BMP** file is optional, and can be used for visually identifying the DOE structure, as explained ahead.

The **.TXT** file contains all information necessary for loading the DOE pattern data into the

LaserWriter. It is a simple text file made of keywords placed after a ***** character and followed by **=** and a parameter value (n).

- XSIZe = n
- YSIZe = n
- XPIXel = n
- YPIXel = n
- XCENtre = n
- YCENtre = n
- LEVEls = n
- TYPE = n

Note that the keywords are case insensitive and only the first 4 characters are used for their parsing. For example, the Xsize keyword is parsed correctly even if it is written as Xsiz, XsiZe, xsize_of_pattern, Xsize_of_bitmap, etc.

Note also that each DOE is supposed to have a rectangular area, and to be made of pixels all with same size and shape. The value of each parameter following the **=** symbol must be set according to the table below:

Xsize	n is the number of pixels in x direction, that is the horizontal size of the pattern, using one pixel as the measurement unit.
Ysize	n is the number of pixels in y direction, that is the vertical size of the pattern, using one pixel as the measurement unit.
Xpixel	n is the width of each pixel, using 1 micron as the measurement unit. Example: 2.44 indicates a pixel width of 2.44 micron.
Ypixel	n is the height of each pixel, using 1 micron as the measurement unit.
Xcentre	n is the x position the the DOE centre, using 1 micron as the measurement unit.

Ycentre n is the y position of the DOE centre, using 1 micron as the measurement unit.

Levels n is the number of grey levels, that is the number of different thickness values contained in the **.DAT** file.

Type n indicates the data format in the **.DAT** file.
For n values from 1 to 7 the data are meant in alphanumeric format, and the grey level of each pixel is indicated with n characters. Values of 8, 16, 32 mean that each level is defined respectively as a 8, 16, or 32 bit binary value. Other values are not allowed.

Example:

* Xsize_of_bitmap = 200
* Ysize_of_bitmap = 800
* Xpixel = 4.00
* Ypixel = 3.20
* Xcentre = 10000
* Ycentre = -200
* Levels = 64
* Type = 3

This **.TXT** file describes a DOE made of a 200x800 pixel array, where each pixel is 4 micron wide and 3.2 micron high.

The pattern is centered around the position 10000, -200 micron and is made of 64 grey levels, with actual values from 0 to 63.

The grey value of each pixel is formatted as a 3 digit string. Hence, the **.DAT** file is 3*200*800 byte long.

When the **.TXT** and **.DAT** files are imported, an LDF file must be created from them, before patterning. This is made, as usual, from the main menu of LaserDraw. This automatically recognizes the binary or multilevel nature of the job, and activates the proper converter.

The LDF file includes a header obtained from the data in the **.TXT** file, with the addition of other job specific parameters (the size of the frame that includes the pattern and the lens selected) and the actual pattern data, obtained from the **.DAT** file. These data are included in the LDF file always as one-byte values for each pixel. Moreover, whichever the declared number of level is, each pixel in the LDF file is associated to one byte and handled as 256 level pixel.

As mentioned above, the **BMP** file is optional. It is an image file, with Windows bitmap format. If available, it is used by LaserDraw just for displaying a figure that the user may have associated with the **.DAT** file.

For example, if the **.DAT** file contains a DOE, its designer can decide to create also a standard bitmap file showing a detail of the DOE or the image formed by the light after going through the DOE. This bitmap, if available at **import** time, is added into the archive, with the same job number of the .DAT file, and shown when selected. The user can simply create the bitmap file by extracting it from the graphical design data and saving it as a Bitmap file, with the same name of the data file it derives from.

Bitmap source files

Although the use of a DAT file and its TXT companion file is the normal procedure for generating a grey level pattern, in certain circumstances the user may find convenient the direct use of a grey level image. For such case, LaserDraw can accept a bitmap image, with standard **.BMP** format, in place of DAT+TXT files. When a bitmap is imported, the user is requested to enter the pixel size and the position of the pattern, as a BMP file does not contain information of such parameters. From the original BMP data and the user supplied information, the DAT and TXT files are created. The BMP file remains in the archive, just as a visual help when the user browses into the database.

Note that the **.BMP** file to import must contain no color information. It had to be a pure grey level “black and white” file, as the color information has no meaning in this context, and may produce a wrong set of grey levels.

Patterning

A multilevel job is selected from the database is automatically recognized by LaserDraw and indicated as “multilevel” in the main menu. As this type of pattern can be made both in beam scan mode and in stage scan mode, the related option buttons are enabled accordingly.

The same START procedure is used for binary and multilevel pattern. The only difference is related to the use of the exposure parameters, that is *gain* and *bias*. The selection of appropriate settings for multilevel exposure and contrast optimization is part of the specific operator training course held by MICROTECH personnel at installation time.

Step by step operator's guide for patterning in *beam scan* mode.

(read the LaserDraw section of the system manual first)

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1) Start the whole system by pushing the <1> button in the UPS front panel.

2) Wait until Windows starts completely and the mouse indicator is a stable arrow.

3) Double-click on the "LW0" shortcut. From now, the interferometer (if installed) requires about 4 minutes to warm-up. While waiting, you can initialise the XYZ microtranslation stages, select to data file to use or edit a new one.

4) XYZ initialisation is required automatically. Follow the pop-up indication appearing in the main menu page.

5) If the mask pattern will be the same as the previous run, there is no need to select it again. If a new pattern is required, you can select it from the database, edit it or import it from a floppy, USB stick, CD or a network resource.

6) For editing a new pattern with CleWin:
   - From the LaserWriter main menu, click <Data management>.
   - The name of the current "active job" is shown in the field at the bottom of the screen.
   - From the "Data management" menu, click <Layout editor>. This opens the CleWin layout editor. If the current active job is "binary" type, this will be automatically shown in the CleWin window. Otherwise, an empty layout is shown.
   - You can edit and modify the current job, or create a new one, according to CleWin menus.
   - Save the project in the C:\ARCHIVE\TEMP folder. Any name can be assigned to the saved file. This is just temporary. When the file will be imported into the system database, it will be given a numeric identification name (xxx.CIF).
   - Exit CleWin.
   - From the "Data management" menu, click <Import>.
   - Select the file to import into the system database, typically from the C:\ARCHIVE\TEMP folder.
   - The "Import" procedure will assign automatically a number to the new project. Add your title, author and comments.
   - Select the archive to use for saving the new project (arch_1 to arch_10), click <Save> and exit the "Import" procedure.
   - From the "Data management" menu, click <Select>. This opens the system database.
   - Select the archive where your job file is, and the file, by clicking on the corresponding field (first column of the table). You can select a file just created or an old file. In the job selection page, note the small check fields

on the left, above the database table. For each record pointed in the table, this fields indicate the format already available on disk. If the file is just created, only “CIF” is checked. If the file has already been used for patterning, both “CIF” and “LDF” are checked.

- Click “Select” and exit the job selection procedure.
- Now the selected file appears in the field at the bottom of the “Data management” page.
- Exit “Data management” and return to the main menu page.

7) Now the selected file appears in the “Job selection frame”, as well as the file type, *binary* or *multilevel* (if the selected job number is not properly indicated, enter “Data management” and exit again).

8) If the active job is new, you may note that the LDF check field is not checked. In that case, simply click the <Make LDF> button, in order to covert the CIF file into the LDF format (this is the format used internally by the LaserWriter for its operation). Otherwise, skip this point. Note that the content of the LDF file depends on the final focusing lens that the operator is willing to use, that is the desired resolution. In the small window related to the make of the LDF file, the current focusing lens is indicated. The system reads this lens from the position of the sliding lens holder (if installed). If you want to pattern with a different lens, simply enter the lens number (2,3,4,5) you want to use. For example, lens #4 for a resolution around 2 micron o lens #5 for a resolution around 1 micron. Then press <GO> and wait for the LDF file creation. Note that each time a change is made on the orginal CIF file, a new LDF file must be created.

9) From the main menu page, click the <START> button. The left side of the “Start” window is automatically enabled, that is the side devoted to manual operation.

10) Measure the thickness of the substrate (in micron) and enter it in the <substr.> field, in the “lens” frame, followed by <enter>.

11) Click <set z> in the “lens” frame. The Z axis will move in order to bring the vacuum chuck in a position close to the focus position for the substrate, when this will be placed on the chuck.

12) Push the <UNLOAD/LOAD> button and wait for the chuck to move toward the operator.

13) Place the mask on the chuck, against the mechanical stops.

14) Click “Ok” for loading the substrate.

15) Turn on the vacuum pump. After a few seconds, the “vacuum ok” indication should appear, against a green background.

16) If the substrate has a high quality surface (a polished wafer, a mask), you can move the <focus rings> slider. This enables the “focus rings” and lets you observe

how far you are from the perfect focus Z position. Move the <focus rings> slider, until the rings appear. If they are outside the green frame, or if they are very small, move the Z axis until they fit sharply inside the left and right side of the green frame. For lens #5, the focus rings should be manually regulated for a diameter around 3 cm, and 4- 5 cm for lens #4. Note that the step of the Z axis (that is, the Z movement for each click of the PgUp or PgDwn keys in the keyboard) has a default setting for each focusing lens, but can be changed by entering the desired value in the Z-step field.

17) If the outer ring is sharply white against a dark background, click the <auto> button in the “focus (rings)” frame. The system will automatically move the Z axis to the best focus position. If the rings are not sharp, this means that the best focus condition was previously stored for a different substrate, with different surface reflectivity. If this is the case, please follow the instruction in LaserDraw section of this manual, in order to store new best focus conditions for the new substrate.

18) Select the beam attenuator, by clicking a transmission value in the “filter” frame. If no change occurred in the photosensitive material, skip this step and keep the previous selection. Typically, for 0.5-2 micron thick resist, the 1% or 3% filters should be used.

19) During the previous steps, the interferometer (if installed) had probably enough time to warm up. Click the <reset> button close to the Y position display. After reset, all indicators in the interferometer position display should be green, and the display should indicate random values around 0,0. Also, the 2+2 small indicators in the interferometer position displays should become green. If this is not the case, the interferometer is not ready yet. Wait a bit longer and occasionally click the <reset> button, until the interferometer actually resets.

20) At this point the interferometer (if installed) is initialised, the autofocus system is initialised and the system is ready for the automatic patterning process. Click the **>** button. This disable part of the commands in the left part of the <START> window, and enables the right part, devoted to patterning. The pattern is shown in the upper window.

21) Select the patterning options (mirror, reverse) and the exposure level (*gain* only for binary patterns and *gain+bias* for multilevel patterns.)

22) Enter a proper D-step value. D-step divided by ten is the distance between scan lines. A value of 1 indicates that two subsequent scan lines are shifted by 0.1 micron. A value of 10 indicates a shift of 1 micron. The higher D-step, the lower the total patterning time (but lower line quality. With lens no. 5 a D-step of 2 to 5 is suggested. With lens no. 4, a D-step of 3 to 8.

23) Select the autofocus mode (*none, plane, rings*). If the substrate is a good planar surface, *plane* should be selected. Otherwise, if the resist layer on the substrate and the surface itself are uniform and without evident defects, select the *ring* option.

24) Press <GO> for starting the pattern. After a list of messages in the bottom scroll window, the XY stage is automatically positioned at the beginning of the first strip and patterning starts.

25) While patterning, the “line #” display in the lower part of the screen shows the current scan line of the current strip, and switches to light blue to blue when the beam is on.

26) NOTE: if you want to make some test exposures, use the “pause” option. This stops the system after each strip, waiting for the “space bar” to be pressed. While the system is in stand-by, the operator can modify the exposure settings.

27) When the pattern is completed (see the message in the scroll window), press **<** to return to the manual section and unload the substrate.

For switching the system off:

- close Windows;
- wait until a message appears on the computer display, indicating to turn off the system;
- Push the red “emergency stop” button on the system cabinet, or the small “0” button in the UPS front panel.