GENERAL TRAINING MANUAL FOR JOBIN YVON HORIBA THIN FILM GROUP END POINT DETECTION EQUIPMENT.

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Formerly

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Overview of End Point Detection.

The Jobin Yvon Horiba (JY Horiba) Thin Film Group's end point detection tools have previously been sold under the Sofie brand name. They are based around a series of modules

combinations allows a tailored solution to a particular end point problem to be provided.

- Interferometry
- Optical Emission Spectroscopy
- Ellipsometry
- Plasma Diagnosis using a Langmuir Probe.

In the following two sections a brief introduction to the main end point detection methods, namely interferometry and optical emission spectroscopy, will be given. Additionally the particular advantages of the JY Horiba end point detection systems will also be stressed.

1.1 Interferometry.

Interferometry relies on an external light source which is directed onto the sample. The reflected light is detected and analysed, see the following figure.

General Setup and Components of a Refleectance System
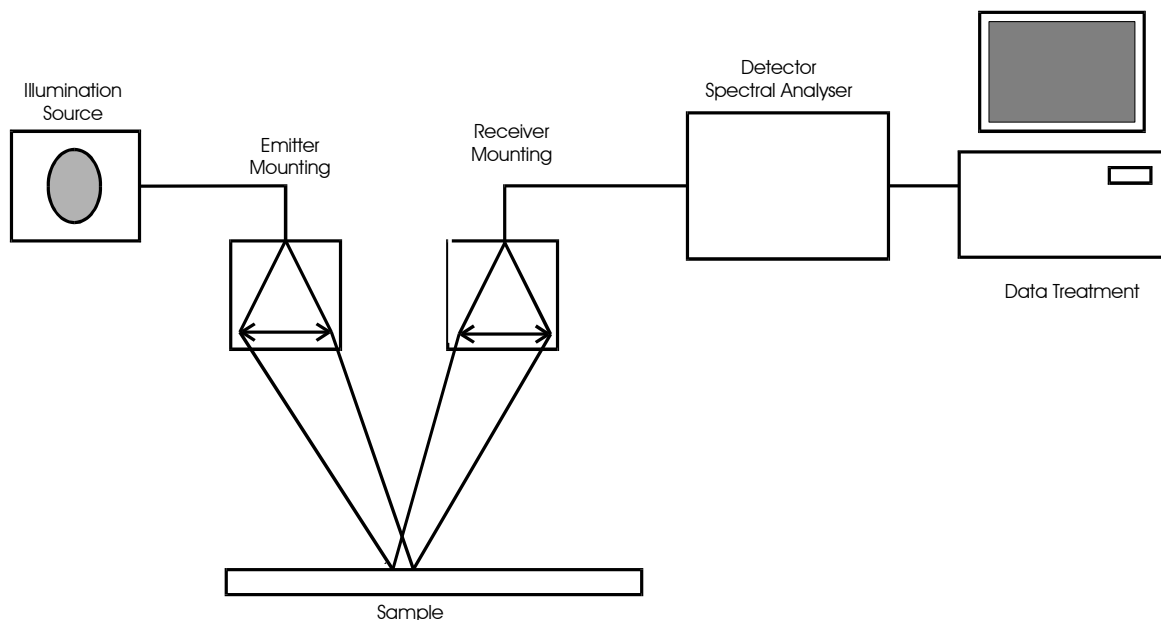
The signal may change during etching when a layer with a different reflectivity is exposed. This gives a sudden step change in the signal level. This type of behaviour is observed when the sample is opaque to the incident light. This type of measurement is termed reflectometry.

However, if the layer in the sample is at least partially transparent then the light reflected off the top and bottom of the layer will interfere with each other, see diagram.

Incident Beam   Reflected Beams

Layer 1

Layer 2

Substrate
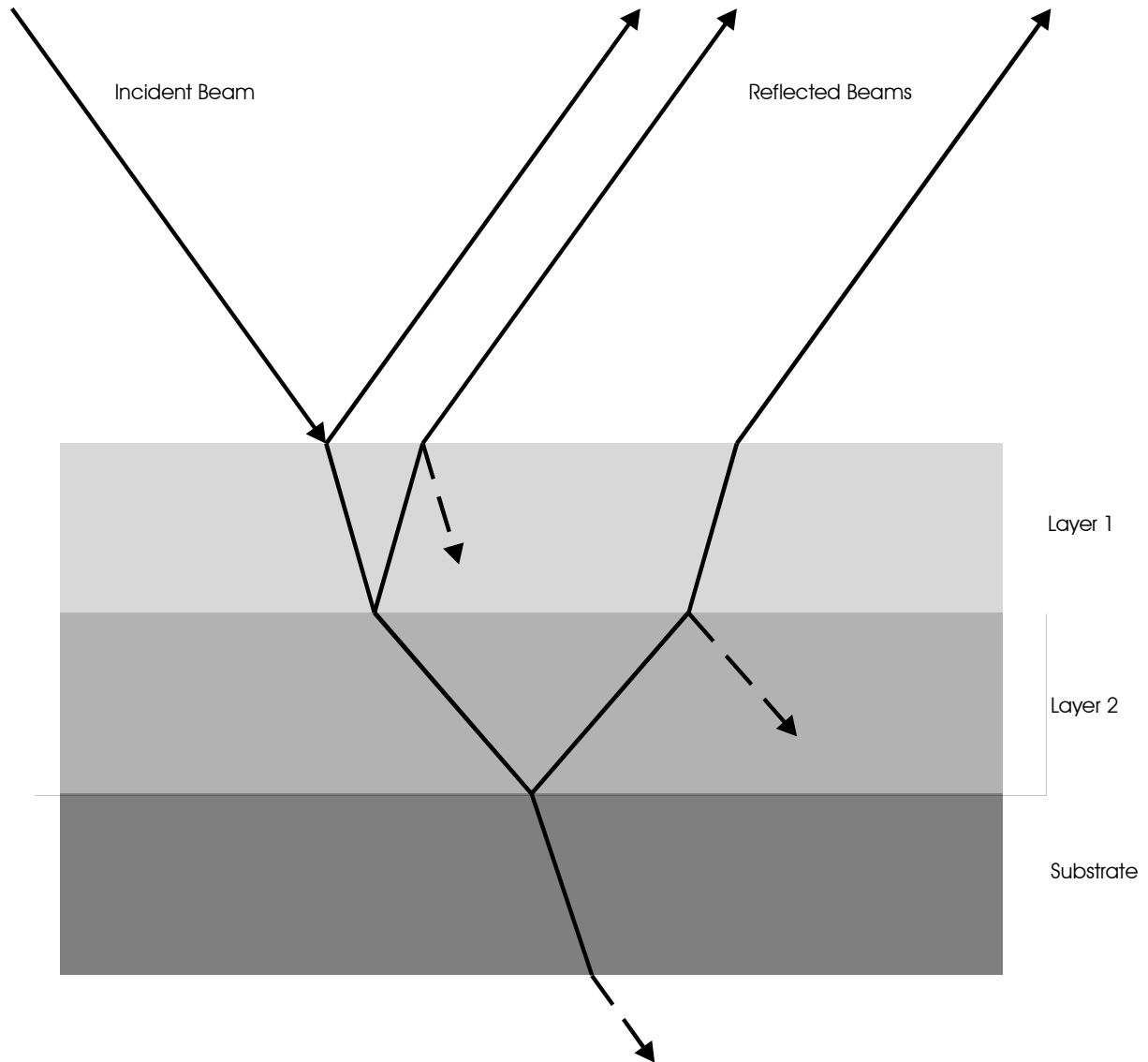
Principle of Reflectance Interferometry

At different layer thicknesses constructive or destructive interference occurs. This leads to a sinusoidal change in the signal intensity as the layer thickness reduces. Each period of the oscillation is often referred to as a fringe. It is possible to count the number of fringes, and in fact parts of fringes which occur during an etch. If this is c then the etch depth d is given by;

$$d = c\mathbf{l}/2n$$
where $\mathbf{l}$ = light wavelength
n = refractive index of layer where interference occurs.

This fact allows interferometry to be used to end point an etch at a given etch depth.

JY Horiba interferometric systems are normally supplied with a camera head. This contains a light source and also has a video camera. This allows the small measurement area to be viewed. The camera is mounted on an XY table, which may be motorised, so the spot can be moved to the correct area of the sample. If the measurement area is small and it cannot be repeatedly located at the correct position a pattern recognition option is available. This automatically moves the camera to bring the measurement spot to the correct point on the sample. The light source is often a laser diode mounted in the camera head.

The light reflected from the sample, which often contains interference information is detected by a silicon photocell and this signal is passed back to a main control unit for further processing. However the available laser wavelengths, which are typically 670, 830 or 905nm, do not always give the best interference signal. If different wavelengths are required alternative light sources are available, in particular a xenon lamp may be used in combination with an interference filter. This type of system is termed a white light interferometer. In this case the lamp is mounted in a separate box and the light is fed down an optical fibre to the camera. The return light is fed back down a fibre optic cable to the main unit. The light normally passes through an optical filter so that only the signal from a limited wavelength range is measured. The light is usually detected by a high sensitivity photomultiplier tube. This transforms the low level light signal into an electronic one.

Alternative types of optical head are available if the camera design is not suitable. These include a system which illuminates several square centimetres of the sample. This type of arrangement can be suitable for complex highly repetitive masks. However it has the potential disadvantage that the average interference signal from the whole illuminated area is measured. This can reduce the accuracy of the technique, although it does provide a degree of averaging over a region of the sample.

1.2 Optical Emission Spectroscopy.

Optical emission spectroscopy (OES) is the monitoring of light generated by the plasma. Different species in the plasma emit light at different characteristic wavelengths. Measurement of the amount of light at a specific wavelength allows a relative measurement of the quantity of a given species to be obtained. This type of measurement is primarily used to determine an end point at a boundary between two layers. In this case the end point is observed as a sudden change in the signal level. The abruptness of the signal change gives an indication of the uniformity of the etch across the area of the wafer. These systems can also be used for impurity analysis and to help give a mechanistic understanding of the process. A generalised schematic diagram of an OES system is shown below.

There are two potential issues which must be considered when deciding whether to use the OES technique. Firstly as the open area of the etch decreases the signal level also reduces. JY Horiba systems have high quality detectors and amplifiers to minimise the signal to noise level. Also extensive software signal processing algorithms are available to allow small open areas to be monitored. Whilst systems are offered using optical filters as a spectral analyser, monochromators are normally used. This is in part due to the fact that the wavelength monitored can be changed, to allow alternative lines to be examined using the same hardware. However monochromators can be easily produced with a sub nanometre bandwidth. This compares with 2 to 3nm of a good interference filter. This reduction in bandwidth decreases the component of the signal which is due to background light within the plasma. This light does not change at the end point, therefore by reducing this light the change due to the end point is increased. The second limitation of the technique is that it is not possible to end point within a layer as there is no associated change in the light output of the plasma. However, this type of end point can be determined using interferometry.
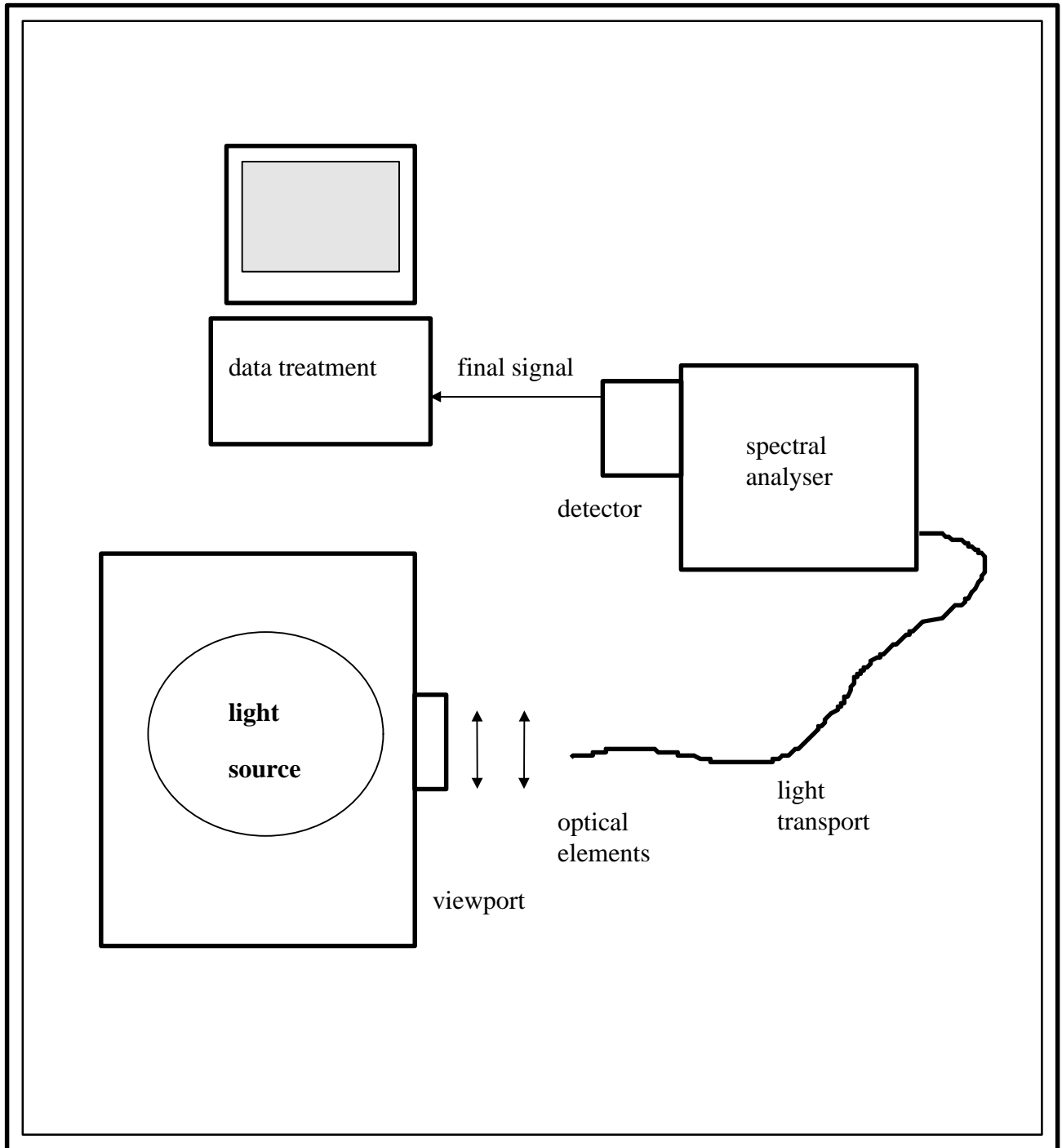
A generalised schematic diagram of an OES system.

1.3 JY Horiba standalone DIGI family systems.

The general construction of the measurement tools has been described above. A standard system has the ability to control two tools. These may be of the same or different types. The use of twin OES systems allows measurements to be made at different wavelengths simultaneously. Alternatively a combined OES and interferometer system is available as a DIGITWIN. This type of device is useful as a process development tool, to allow the optimum end point technique to be determined. It also finds uses in the control of multiple step processes, where different steps require both OES and interferometric end pointing. If more than two tools are required then multiple systems can be combined and controlled from a single user interface This allows additional data to be collected from a single chamber, or to control cluster tools with multiple chambers.

The software which controls the system and processes the collected data is one of the major advantages of the JY Horiba end point detection systems. The hardware is fully controlled by the software. In addition powerful data analysis functions are included which allows the reliable extraction of end point conditions from complex data sets. The software has the ability to end point on simple level or derivative thresholds which may be used for simple OES signals. In addition the software can count interferometric fringes and this enables the etch to be stopped at a given etch depth. Also if a pair of interferometric signals from the same sample area but at different wavelengths are used a special algorithm has been developed which allows the remaining thickness of a layer to be determined.

2 Description of typical systems.

The systems which are most commonly supplied are either single channel interferometers, these are termed DIGILEMs, or Optical Emission Spectrometers, which are called DIGISEMs. However, the systems are designed to be able to control two sensors simultaneously, for example an interferometer and a spectrometer can be incorporated into a single system (DIGITWIN).
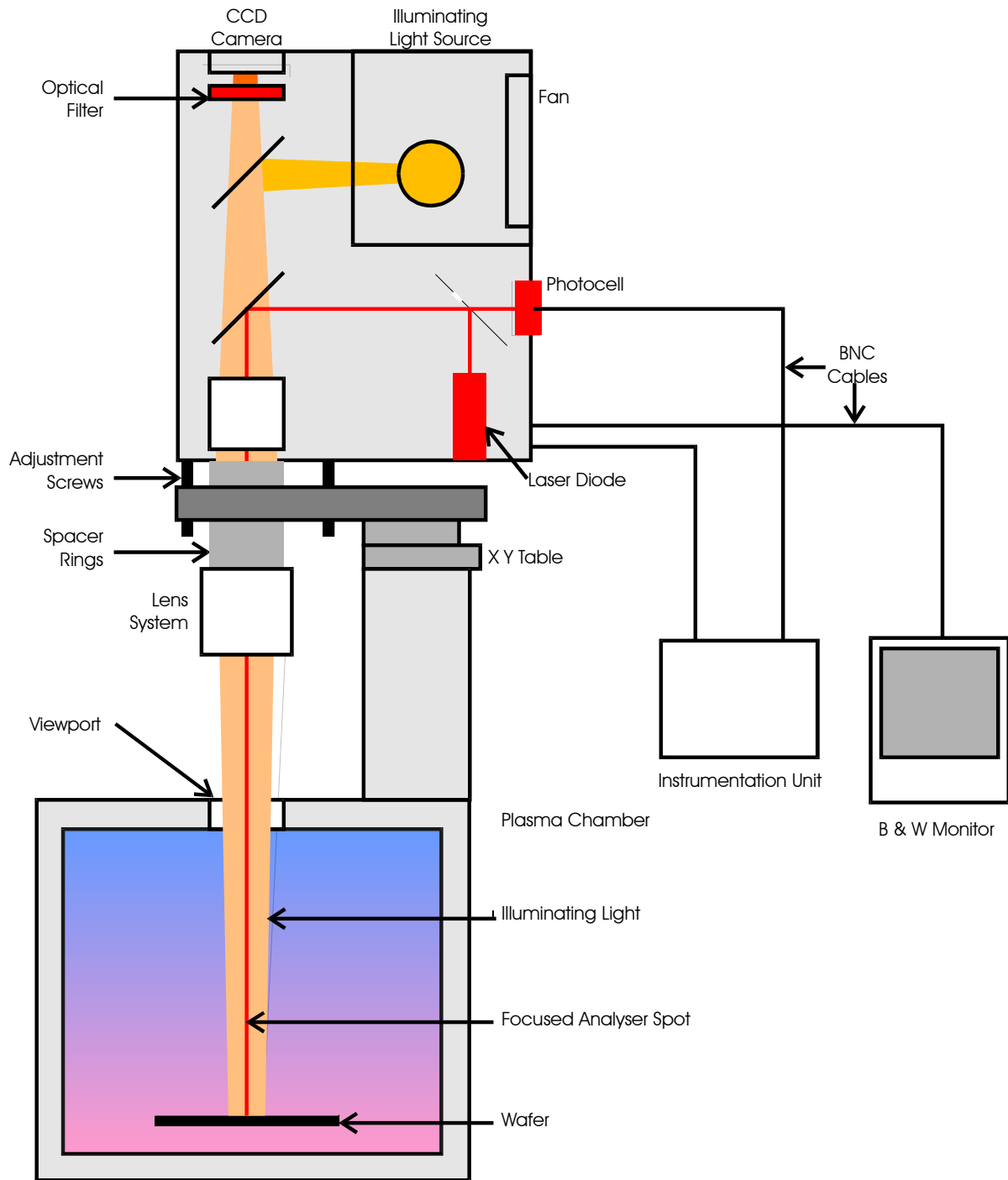
2.1 Interferometers (DIGILEMs)

These consist of two distinct types; laser interferometers (F11-201-005) and white light interferometers (F11-201-009)

The diagram on the following page shows the main components of a laser interferometer system. This shows an interferometer camera which is located above a top window in the etch chamber. The camera is connected to a monitor to allow the image from the camera to be seen. The signal from the detector is fed into the central acquisition and treatment unit. This contains among other items a computer. This has connections to the normal colour monitor, keyboard and trackball or mouse.

The white light systems are slightly more complex in that an external xenon light source is provided. This is a half width 3U enclosure containing a 75W xenon lamp with a power supply. The light is passed down an optical fibre to the camera where it then follows the same optical path as the laser light in the laser interferometer. The return light is also passed down an optical fibre to the central control unit. These systems use a photomultiplier tube (PMT) housed in the central unit, rather than a silicon cell on the camera itself.

The camera is mounted on an XY table so that the measurement spot can be moved relative to the wafer. This can either be a manual device or the system can have a motorised table (F23-042-040). The latter allows the table to be moved from the computer directly. This is useful if the etch chamber and therefore the camera are not located in the clean room. It is a requirement for the pattern recognition option. This option is generally used for systems in production fabs and special installation information will be provided with any deliveries containing pattern recognition hardware.

Schematic Diagram of the Microspot Interferometer with Sample Observation

Diagram labels:

- CCD Camera
- Illuminating Light Source
- Optical Filter
- Fan
- Photocell
- BNC Cables
- Laser Diode
- Adjustment Screws
- Spacer Rings
- X Y Table
- Lens System
- Instrumentation Unit
- B & W Monitor
- Viewport
- Plasma Chamber
- Illuminating Light
- Focused Analyser Spot
- Wafer

2.2 Optical Emission Spectrometers (DIGISEMs)

These systems are in many ways less complex than DIGILEMs. The light is simply collected by a fibre which is normally mounted on a chamber side window. The light passes down the fibre to a central data acquisition and treatment unit which is very similar to that used in the DIGILEMs. The major difference is that the light passes through a monochromator which selects a single wavelength (or colour) of light. Only this one wavelength is passed onto a PMT detector. There are several different types of monochromator available. They have different focal lengths and thus have different resolutions. The larger the instrument the better the resolution, which means that the band of wavelengths which is measured is smaller. This is required for complex plasmas where many lines from different species tend to overlap. However, as far as the end user is concerned these different types of spectrometer behave similarly.

It should be noted that in addition to process monitoring, by positioning the spectrometer at a single wavelength, all JY Horiba OES systems incorporating a monochromator can also be used to take a spectrum of the plasma emission. This involves collecting the signal intensity at each wavelength in turn. This is very useful tool both for fingerprinting plasma emissions and for aiding in the selection of the optimum plasma line for end point detection.

2.3 Interfacing to Etchers.

The final major difference between units is the choice of interface to the etcher. Unless the JY Horiba system is operated manually (i.e. in standalone mode) information is passed between the etcher and the JY Horiba end point detector. In general these items are described as the remote control interface (F23-041-050). However, the interface can be configured in many different ways depending on the etcher to be interfaced to. Specific details for a particular etcher configuration can be supplied on request.

3 Safety Precautions.

The user manual should always be referred for full safety information and this should be read carefully before using the system. However the main areas where safety is a specific issue are outlined below.

3.1 Laser Radiation from laser interferometers.

The standard laser interferometers emit laser radiation and care must be taken not to look into the laser beam.

3.2 UV Radiation from white light interferometers.

The xenon lamp emits significant quantities of ultra violet radiation. Direct and indirect eye exposure must be avoided. UV protective goggles should be used. The light is present inside the lamp housing. It is emitted from its aperture and even when an optical fibre is attached significant amounts of UV radiation can be emitted from the other end of the fibre.

3.3 Lamp replacement in white light interferometers.

Specific procedures must be taken before replacing the xenon lamp in the white light interferometers. The information in the manual must be read before undertaking lamp replacement. It is important that these instructions are strictly adhered to.

4 Hardware connections for DIGILEMs.

WARNING: The white light systems have fibre optic connectors. These must be treated with care as they can be broken relatively easily. These fibre optic cables must never be bent to less than a 100 mm radius and if the fibres are to be left for more than a few minutes they must not be bent to less than a 300 mm radius. The fibres must also not be dropped and care must be taken to keep the ends of the fibres clean and dust free. If these precautions are not adhered to the fibres can be broken. This will result in a significant but not necessarily complete lack of light transmission down the fibre, and the only method of repair is to replace the fibre optic cable which is not an insignificant cost.

Diagrams of the various basic hardware configurations are given in the manual which accompanies the system. The details of the connections will be discussed below. The details of the remote control connections depend on the particular etcher that the JY Horiba system will be interfaced to. Details for connections to specific etchers are available on request. It should be noted that it is normal to verify the correct operation of the DIGILEM in a standalone mode before attempting to connect it to the etcher.

4.1 Connections relevant to both laser diode and white light systems.

4.1.1 Power Connections.

WARNING: The power supply requirements of the devices should be checked before connecting the units.

The main unit and computer monitor are supplied with separate cables with a UK mains plug on one end and a standard IEC plug on the other. The black and white monitor for the camera video image is supplied with a fixed power cable terminated with a UK mains plug.

4.1.2 Computer Connections.

The computer monitor, trackball and keyboard are connected to the sockets marked appropriately on the back of the DIGILEM unit. These connectors are similar to those found on standard computers. If a printer is to be used it should be connected to the 25 way male printer port of the computer section. This is marked but care should be taken not to plug it in to the remote control connector.

WARNING: The printer must be switched off before connecting it, otherwise damage to the controller unit may occur. Please note that only printers of the type supplied by JY Horiba will work with the software.

4.1.3 Acquisition Connections.

The system consists of an acquisition board mounted on the computer motherboard and further electronics normally located within the same box. These are connected by a pair of cables. One is a 9 way female to female cable which transmits the analog signal information. A second 25 way female to female cable passes additional digital information. These two cables directly connect two connectors on the back of the acquisition board to a pair of connections on the back of the DIGILEM unit. These connections are marked analog and digital on the acquisition board and analog in and digital in on the back panel.

4.1.4 Camera and Monitor Connections.

The signal output of the camera depends on the type of system and each type is discussed below.

The camera is supplied with power by a 15 way male to 7 way round connected cable. This should be fitted between the camera connection on the DIGILEM and the multipin socket on the camera itself. A BNC - BNC cable is used to connect the video output from the camera, located near the bottom to a black and white video monitor.

The video input should be connected to the video in connector of the video monitor. If the video out port of the monitor is not used the impedance switch should be set to 75 ohms, if another device is connected the switch should be set to the high impedance position.

4.1.5 Motorised XY Table Connections.

If a motorised XY table is fitted the two separate axes are powered using a pair of 15 way female to 15 way high density female leads. These connect between the motor and extended motor connectors on the back of the main unit to the XY table. The connector from the motor socket should be connected to the X axis. This is the horizontal motion in the video image. This correlation can be changed within the software.

4.2 Connections specific to laser diode systems.

The only additional cable which is required for these systems is the one which transmits the signal level back from the camera to the main unit. This is a BNC to BNC cable which connects to the camera approximately half way up the rear of the camera. This is connected to the signal in connector of the main unit. It should not be plugged into the V_{out} connector which, if fitted, is located near to the signal input.

4.3   Connections specific to white light systems.

These systems have an additional light box. This is supplied with a separate mains power input. Additionally the fibre optic which is attached to the bottom of the camera should be plugged into the light output of the light box. This connection should only be made hand tight to avoid damaging the fibre optic.

Additionally there is a separate fibre optic cable which connects from the centre of the back of the camera to the signal input of the main unit. The end of this fibre which connects to the main unit also contains an optical filter. The specification of this filter depends on the type of etch which will be end pointed and it therefore varies. Care should be taken to ensure that the correct fibre, and hence filter, is used. This connection is the basically same as in the laser systems, however in this case the cable is a fragile fibre optic link. Again the connections should only be made hand tight. However, care should be exercised to ensure that the connector on the main unit is pushed home. If this is not achieved a micro switch in the connection is not actuated and this prevents any high voltage being applied to the photomultiplier tube (PMT) within the main unit. This causes the signal output to be almost zero even when light is transmitted down the fibre. This switch acts as a safety device to prevent the PMT being energised when there is no fibre optic attached. In this case too much light will strike the PMT and this can cause temporary or, in extreme cases, permanent damage to the PMT.

5 Interferometer Camera Alignment.

A Diagram of the layout of a laser diode camera is given in section 2. The white light camera is similar in design, except that the laser diode is replaced with the end of a fibre optic cable which connects to the external white light source. Various sized apertures are placed at the end of the fibre optic to limit the spot size on the wafer. Finally the photocell is replaced with a further fibre optic which connects back to a photomultiplier detector in the main unit.

If the camera is being tested before fitting to the etcher then the camera should be placed at a typical distance above a wafer. It should also be mounted so that the bottom face of the camera is approximately parallel to the wafer.

Once the camera and the control unit have been correctly connected the equipment can be turned on. During this procedure the software in the system will start to load. At this point in the testing the software can be ignored. However if a motorised XY stage is present it should be noted that during the software startup the XY stage will move as the system finds the limits of the travel of the table. The procedure to check the correct operation of the XY stage is given in section 8. It is therefore best to wait for the software to complete the initalisation of the XY table before attempting to carry out the procedures described below. This avoids any chance of damaging the camera if it moves unexpectedly.

The majority of the alignment is the same for both laser and white light systems. There are some additional adjustments which should be made for the white light systems and these are described in section 5.3. Initially the white light systems should be aligned with no aperture in place. Both the laser and white light systems place a small spot of light on the surface of the wafer and this can be seen in the video image. This light is used to measure the change in reflectivity or interference in the sample, therefore, this will be referred to as the measurement spot.

5.1 Setting Camera Focus.

Initially the distance between the camera lens and the wafer should be estimated. The camera lens should be carefully unscrewed and the correct extension tubes (spacers) should be fitted. The appropriate tubes can be selected from the table below. The lens is then replaced.

Extension Tube Thickness (mm)	Minimum Focus Distance (mm)	Maximum Focus Distance (mm)
1	400	630
5	255	330
10	180	212
15	140	160

The image from the camera should now be viewed on the black and white monitor. If the image appears dark or too bright the camera aperture should be set to 4.

The camera image should be able to be taken through focus using the normal lens focusing adjustment. If this is not the case either various thin extension tubes can be inserted to give the correct vertical position of the lens, or the whole lens can be moved up and down.

WARNING: Before attempting to move the lens ensure it is held firmly to prevent it falling and causing damage.

The camera lens is held in place by a locking screw located inside the camera. Access to the screw can be obtained through the hole in the front of the camera near the bottom. An Allen key is needed to loosen the screw. The lens can now be moved up and down until the image comes into focus. Lock the lens back in position and the final focus is achieved using the focusing adjustment on the lens itself.

The distance between the camera lens and the wafer changes the magnification of the camera. The correlation is given in a graph within the manual.

When focusing the camera it is best if a patterned wafer is used. It is very easy to focus onto the chamber window and the identification of the wafer pattern eliminates this possibility. When the camera is in focus both the image of the wafer and that of a small bright spot should be visible. This small spot is the light which is used to measure the interference within the sample. Thus it is termed the measurement spot. This must be placed at the sample position where the measurement is required.

5.2   Setting Camera Tilt.

The position of the camera must now be adjusted so that its optic axis is perpendicular to the wafer. This allows the light reflected back off the wafer to be collected by the camera. This alignment is achieved by moving the adjustment screws, shown in the diagram of the camera head.

The camera aperture should be slowly reduced and the screws adjusted so that the iris appears centrally within the image. The measurement spot should also be visible in the centre of the screen.

The camera lens aperture should now be set back to 4 and the measurement spot observed as the camera lens is taken through the focus position. The spot should enlarge uniformly as the camera is defocused. If the spot becomes asymmetric the system is said to have aberrations. This is normally due to an error in the camera tilt alignment. If this occurs the camera tilt should be readjusted.

5.3 Additional alignment of white light systems.

5.3.1   Inserting apertures.

The position of the measurement spot should be noted on the screen. The largest aperture should now be inserted the centre of the new spot should now approximately coincide with that previously noted. If no spot appears, or the best position occurs significantly before the end of the aperture's travel then the aperture end stop position requires adjusting. This is not a simple procedure, and should only be carried out by personnel specifically trained to carry out the adjustment. If the spot appears normally the procedure should now be repeated with the remaining apertures. Normally the systems should be set up with the smallest aperture, which will be either 50 or 100 μm, depending on the particular application.

5.3.2   Collection spot alignment.

The light which is reflected from the wafer has to be collected and measured. It leaves the camera by a fibre optic cable. This is connected about half way up the rear face of the camera. The fibre optic contains a light guide which is typically only 500 μm across. Therefore accurate alignment of the position of this fibre is critical. A diagram and a procedure to align the fibre is given in the DIGILEM manual.

There are two different designs of the fibre alignment system. The original system has four screws arranged in two pairs opposite each other. In this case the fibre is moved by releasing one pair of opposing screws enough to allow the fibre to move. The other two screws are moved using a push – pull technique. This means that once the fibre has been released both the screws should be turned in the same direction and at the same time. This requires a pair of 1.5mm Allen keys. The new system has a pair of knurled adjusters which are hidden behind a protective plate. These simply require that the plate is removed and then the adjusters can be moved by hand. Once the alignment is completed the protective plate must be refitted to prevent accidental misalignment of the fibre.

If the camera gives a significant signal on the front panel display the collection fibre alignment can be achieved by maximising the signal level. If this technique is used an unpatterned wafer should be used to avoid the effects of the changing reflectivity of the sample. If only a very small signal is obtained or there are doubts about the collection fibre alignment or focusing the full procedure should be followed.

It is assumed that the previous procedures have been followed. If this is the case the camera will be focused and is set to an aperture of 4. In addition the required aperture should be inserted into the camera. If the aperture alignment is incorrect the following procedure can be followed with no aperture in place. However, if the camera is realigned to correct the aperture problem the following procedure must be repeated.

WARNING: The xenon white light source emits a significant amount of UV light. Wear UV protecting glasses before undertaking the following procedure.

The complete alignment procedure is as follows;

1.   The position of the measurement spot should be marked on the monitor.

2.   Disconnect the illumination fibre from the light source.

3.   Disconnect the collection fibre from the main unit.

4.   Remove the optical filter from the reception fibre, if it is present.

5.   Connect the free end of the reception fibre to the light source.

6.   If the spot of the collection fibre is out of focus the following procedure should be carried out;

   a)   Unscrew and remove the collection fibre from the camera.

   b)   Loosen the fibre lock screw.

   c)   Move the fibre slightly.

   d)   Replace the collection fibre and check the focus.

   e)   Repeat c and d until the best focus position is achieved.

   f)   Retighten the fibre lock screw to secure the fibre.

   g)   Screw the collection fibre back into position.

7.   Align the reception fibre at the back of the camera so that it is coincident with the previously marked measurement spot.

8.   Disconnect the collection fibre from the lightbox.

9.   Replace the optical filter, if removed.

10.   Reconnect the collection fibre to the main unit.

11.   Reconnect the illumination fibre to the light box.

5.4 Setting offset and gain controls on the main unit front panel.

This section applies to all types of interferometer. White light cameras should be fitted with the aperture which will be used for the measurements. This procedure adjusts the two potentiometers on the front panel of the system to eliminate electrical offsets and to give a consistent signal level. The procedure is as follows.

1.   Focus the camera onto a silicon wafer surface.

2.   Set the camera aperture to 4.

3.   Set the gain level to a minimum and place the lens cap over the end of the camera lens.

4.   Adjust the offset control to give 0.00 volts on the display. It is important that the signal is not negative, so if unable to set the system to give exactly 0.00 err on the positive side but keep the value below 0.10. The potentiometer should be approximately in mid position of its range. The value in the window of the control should be between 4 and 6.

5.   Remove the lens and adjust the gain to give 3.60V. This enables the reflectivity of the sample to be directly read from the front panel. If the sample is known to have a different reflectivity this should be used as the target value instead. The value of 3.6 volts may not be achieved so easily for white light systems. In this case the gain should be set so that 8 shows in the window of its control.

6.   Replace the lens cap and check that the signal level is still 0.00 volts.

At this point the camera is now ready for use.

6 Hardware connections for DIGISEMs.

WARNING: The fibre optic from the chamber to the system is fragile. It is protected by a metal casing but it should be treated with care. In particular it should not be bent excessively. The fibre must also not be dropped and care must be taken to keep the ends of the fibre clean and dust free. If these precautions are not adhered to the fibre can be broken. This will result in a significant but not necessarily complete lack of light transmission down the fibre, and the only method of repair is to replace the fibre optic cable which is not an insignificant cost.

Hardware configuration diagrams are given in the manual which accompanies the system. The details of the connections will be discussed below. The details of the remote control connections depend on the particular etcher that the JY Horiba system will be interfaced to. Details for connections to specific etchers are available on request. It should be noted that it is normal to verify the correct operation of the DIGISEM in a standalone mode before attempting to connect it to the etcher.

6.1 Power Connections.

WARNING: The power supply requirements of the devices should be checked before connecting the units.

The main unit and computer monitor are supplied with separate cables with a UK mains plug on one end and a standard IEC plug on the other.

6.2 Computer Connections.

The computer monitor, trackball and keyboard are connected to the sockets marked appropriately on the back of the DIGISEM unit. These connectors are similar to those found on standard computers. If a printer is to be used it should be connected to the 25 way male printer port of the computer section. This is marked but care should be taken not to plug it in to the remote control connector.

WARNING: The printer must be switched off before connecting it, otherwise damage to the controller unit may occur. Please note that only printers of the type supplied by JY Horiba will work with the software.

6.3 Acquisition Connections.

The system consists of an acquisition board mounted on the computer motherboard and further electronics normally located within the same box. These are connected by a pair of cables. One is a 9 way female to female cable which transmits the analog signal information. A second 25 way female to female cable passes additional digital information. These two cables directly connect two connectors on the back of the acquisition board to a pair of connections on the back of the DIGISEM unit. These connections are marked analog and digital on the acquisition board and analog in and digital in on the back panel.

6.4 Fibre Optic Connection to Chamber.

The fibre optic cable connects from a side chamber window to the signal in connection on the rear of the main unit. A suitable flange to connect to the outside of the window is normally supplied. To avoid damaging the fibre optic the connection should only be made hand tight.

7 Basic Software Overview.

The software used by the end point detection systems is highly sophisticated. It allows all of the features of the different types of end point detector to be used. However at the same time it does so using a consistent user interface. The software is fully multitasking which allows multiple sensors to be monitored. It also allows data analysis to be performed whilst the system is monitoring end points.

This section details the main features of the software which are used on a daily basis. The full manual should be consulted for further details and for features not covered. In general functions which are available at any point are shown as buttons on the screen. These can be run by pressing the key shown in reverse video.

7.1 Software Initialisation.

When the software is started the hardware is initialised. Whilst this is taking place a star in a red square is visible in the top left hand corner of the screen. When the hardware initialisation is complete the background of the star turns green. This may take some time if a motorised XY table is present. The user should wait for the hardware initialisation to complete before starting to use the software.

7.2 Running a Process.

When a run is started, either by selecting Process Control-Start Run or by remote control, the currently selected process will be executed. The data is stored in both the batch and reprocessing databases. A process is composed of one or more steps, and a step is defined as a single RF on RF off sequence.

7.3 Defining a Process.

The parameters used for each step are defined in Process Control-Setup Process Control-Step. To create a new step highlight a previously existing step of the correct type (e.g. Interfer.) and press C. Step and recipe names can now be entered. Return moves between fields and escape ends the entry. After creating a step it should be modified so that appropriate parameters can be entered. Details of the step parameters are given in the manual. Existing steps can be modified in a similar way.

Processes are managed in the Process Control-Setup Process Control-Processes menu selection. To create a process press C. Then enter a name and press escape. The process should now be modified, so that steps can be added to it. A step is added by highlighting it and pressing enter. If a non endpointed step is required (e.g. breakthrough) use the – key. Delete removes all the steps in a process. When finished the escape key should be pressed to return to the previous screen. The process which will run is shown with a * before its name. This can be changed by highlighting the required process and pressing S to select a new process.

7.4 Reprocessing a Run to determine the optimum settings.

When the software records a run it is saved in the reprocessing database. This is accessed from the reprocessing menu. The required run can be selected from a list showing the step and recipe names and the date and time of the run. However only the last 500 runs are stored. The reprocessing feature is designed to allow the step parameters to be optimised by reprocessing data with different parameters. So a set which reliably generate the correct end point can be determined. The data can also be saved by exporting it to a floppy disk. Select up to 25 runs by highlighting each and pressing return. The selected runs are shown in reverse video. Press E to export the data. Note any previous runs on the disk are automatically overwritten. The data can also be read back into the software using the import command. Data can also be written to a floppy disk as a text file using the ASCII function.

7.5 Reviewing Previous Data.

Additionally the endpoint region of all runs is stored in the batch database. The software is designed so that all the runs relating to each lot of wafers are stored in a separate batch. A batch for each lot should be created and selected in the Process Control-Setup Process Control-Batches section of the software. Batch information is viewed in the batch analysis menu. This can be accessed in the lower window even whilst data is being acquired in the upper one. To inspect the data, highlight the batch and press S to view the steps associated with it. Then highlight the required step. The summary command gives a graph of end point time and etch rate versus run number. View allows the last 160 seconds of data to be examined.

This section provides an overview of commonly used functions. The manual provides further information and it should be consulted in case of difficulty.

8 Check operation of manual and motorised stages.

This check is really a hardware check. However the motorised stages require a knowledge of the software therefore it has been included after the introduction to the software.

The manual stages simply require that the micrometer adjustments on the translation stages underneath the camera move freely but are not so loose that vibrations would cause the camera to move.

The motorised XY stage should have performed a series of movements on both axes when the software started up. If this was not previously observed the software should be exited with ALT-X and the computer restarted. If the stage does not initialise both axes the system requires further examination.

Once the software has completed the startup checks and the star has a green background the movement of the XY stage can be checked. Select the Process control menu. It is very important that this is done as the XY stage can only be moved from this menu. At this stage press the CTRL and arrow keys to move the table. The change in position should be visible on the camera monitor as a movement of the sample. If the arrow keys do not give the correct movements then these can be changed by going back to the main menu and then to the System Setup-Configurations Param page. This screen has an XY table option. This is a four figure number which defines the relationship between the cursor key and the table movement. The digits of this number can be changed to obtain the correct movement. 1234 is the default number and should work for normal configurations. If no movement of the XY stage is observed then this number should be checked to determine if it is valid. If in doubt enter 1234 as this should provide some movement. If lateral (X axis) movement is obtained when pressing the up and down arrow keys, and vice versa, the cables connecting the XY table should be reversed. The system must be powered down before making the change. If the arrow keys give the correct axis of movement but the wrong direction the digits 1 and 2 or 3 and 4 should be interchanged in the XY table option described above.

9 Checking the operation of a system by taking a run.

It is recommended that initially a couple of runs are taken in manual mode. this Is achieved by setting the remote control and communications links to none. This allows data to be obtained from a wafer without etching it.

Several runs should be taken with a normal set of step parameters. The system should be checked to verify that the system, after the learn time, gives a stable signal level. The magnitude of the signal should be compared to expected values for the system. If the signal saturates, i.e. reaches 100%, the coarse or fine gain parameters should be reduced. The coarse gain parameter for cell based systems (typically laser interferometers) has no effect. If the fine gain is set to one and further gain reduction is required the gain control on the front panel should be reduced.

For DIGILEMs the beam should then be obscured between the camera and the viewport. The signal level should reduce to less than 1%. If it becomes exactly 0.0% then recheck the lcd display on the front panel. If the signal is negative the zero offset should be rechecked, see section 5.4.

If the system operates normally without etching a sample the appropriate remote control and communications links should be established. If a communications link is selected the steps with appropriate names should be created. If not the process with the correct steps should be selected in the software. Now a sample should be etched. The system should start automatically when the RF is turned on. The data obtained should be compared to that previously observed, and if significant differences are observed further investigation is required. It may be necessary to fine tune the step parameters to obtain a reliable end point. This is normal as minor variations do occur both within the JY Horiba system and between etch chambers. The normal method of parameter optimisation is by using the reprocessing functions of the software. However this is really outside the scope of initial instrument testing. It is normally sufficient to check that the end point signal is received by the etcher. This can be achieved simply by pressing the END key during the run.

10 Correct DIP switch settings for various boards.

SOF 30721 Acquisition Board Channel 1 DIP Switch Settings

	1	2	3	4	5	6	7	8
ON		■		■				■
OFF	■		■		■	■	■	

SOF 30721 Acquisition Board Channel 2 DIP Switch Settings

	1	2	3	4	5	6	7	8
ON		■						■
OFF	■		■	■	■	■	■	

SOF 40930 Remote Card DIP Switch Settings

	1	2	3	4	5	6	7	8
ON		■	■			■	■	■
OFF	■			■	■			

SOF 40950 and 41980 Cards DIP Switch Settings for TTY communications only

	1	2	3	4	5	6	7	8
ON		■		■			■	■
OFF	■		■		■	■		

SOF41980 Cards DIP Switch Settings for SECS link only.

	1	2	3	4	5	6	7	8
ON		■	■				■	■
OFF	■			■	■	■		