SpliceLab 2.0 User's Guide

For FSM-100 and LZM-100

Fiber Ball-lens software
Version 2.0

Tech Support
800.866.3602

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1. Introduction

Splicing in a research and development environment often requires tools that are not present in the splicer firmware or are time-consuming to access through the standard splicer menus. To address these needs, AFL developed the Splice Lab environment. Splice Lab is a PC-based research and development system that expands on the capabilities of the FSM-100 and LZM-100 series splicers. Splice Lab consists of a group of files for different functions and applications

This User Manual is to address the application and operation of the ball-lens making with the Excel file ***FSM LZM Ball Lens.xls***.

1.1. General Features of the Program

- Creating, measuring, image archiving fiber ball lens using FSM100 Fujikura fusion splicers series and LZM-100 CO_2 laser glass processor
- Ease to design a ball lens geometry and create machine parameters to repeat the desired process
- Capabilities to drive individual motors, ignite and stop the arc or lase, control the heat power
- Geometry tools that use the algorithms in the splicer to determine fiber diameter, position of splicing point, and distance between any two points of interest
- Enhanced rotation control for overcoming the impact of gravity during the ball-lensing
- With and without splicing for making ball lens with single fiber or two different spliced fibers
- One software applies to 5 different machine types, which includes FSM-100M, FSM-100P, FSM-100M+, FSM-100P+, and LZM-100
- One software applies to different PC systems, such as Windows XP, Windows 7, and Windows 8, 32 and 64 bit platforms, and MS Office 2003. 2007, 2010, 2013.

2. Installation

2.1. Installation Instructions

The current version of SpliceLab is software to control FSM-100 and LZM-100 splicers. The splicer should have installed on it firmware version higher than or equal to 01.019 for the FSM-100 and 01.001 for the LZM-100.

Some basic steps for the software installation and operation are listed below:

1. Install the latest Data Communication software from the CD-ROM.
2. Connect the PC to the splicer with the USB cable
3. If USB cable is connected, a message of "Found New Hardware" may be shown on the right bottom of PC screen, and "Found New Hard Ware Wizard" dialog window may open.
4. Follow the instruction of "Found New Hardware Wizard". You should select "No, not this time" to the question of "Can Windows connect to Windows Update to search for software?". In the next page select "Install from a list or specific location". In the next page, select "Do not search, I will choose driver to install". And in the next page select "FJK-SY-052". Click "Next" and wait for automatic installation. It will take awhile for some PC. Now it is ready to run SpliceLab.
5. Test-run the Data Communication software to be able to get live videos from the splicer connected.
6. Installed to PC the Excel driver for SpliceLab depending on your PC platform (32 bit or 64 bit).
7. The Splicer should be in "READY" mode to run the SpliceLab files
8. Test-run the Ball-lens software by opening the file and observe if any errors occur while the software communicates with the splicer
9. In case you do see errors, please read the PDF file "FSM-100 SpliceLab training" to resolve the problems.
10. In the case you have problems which you cannot solve during your operation, please save the Excel file and e-mail it back to AFL for analysis.

3. Launching Splice Lab

Important Note: Before launching Splice Lab, ensure that the FSM-100 or LZM-100 splicer is connected to the PC by the USB cable, and also ensure that the splicer is in the “READY” condition. If this is not done, a communication error will occur.

Executing SpliceLab files will start the macros embedded in the Excel files. Depending on the version of MS Office you are using, you need to enable the Macro for your version of Excel. Adjust the security level to “middle” or “low” in order to enable macros.

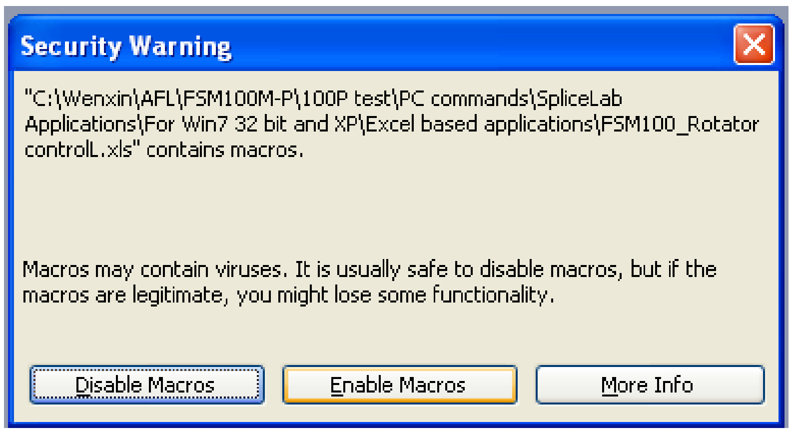


Figure 3.1: ***Tune the security level to “middle” or “low”*** **and** ***click*** **“*enable macros*” for Excel 2003.**

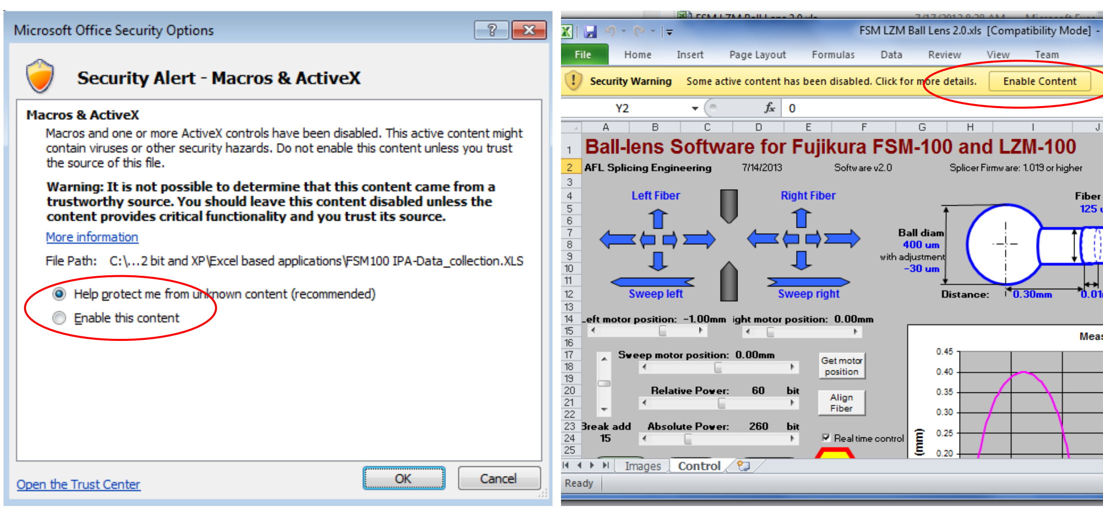


Figure 3.2: ***Tune the security level to “middle” or “low”*** **and** ***click*** **“*enable macros*” for Excel 2007 and 2010.**

For more information on changing the security level, please read the following online instructions by Microsoft.

For Office 2003, please read

[Enable macros to run for Excel 2003]

For Office 2007, please read

[Change macro security in Excel 2007]

For Office 2010, please read

[Change macro security in Excel 2010]

Figure 3.3: Online instructions by Microsoft for changing the security level

Right after launching the Excel file, the background macro will communicate with the splicer to determine the "machine type" (splicer model) information as well as the serial number. If you see the correct serial number displayed on the top-right of the "Control" page of the ball lens GUI, the communication between the splicer and the PC has been established successfully.

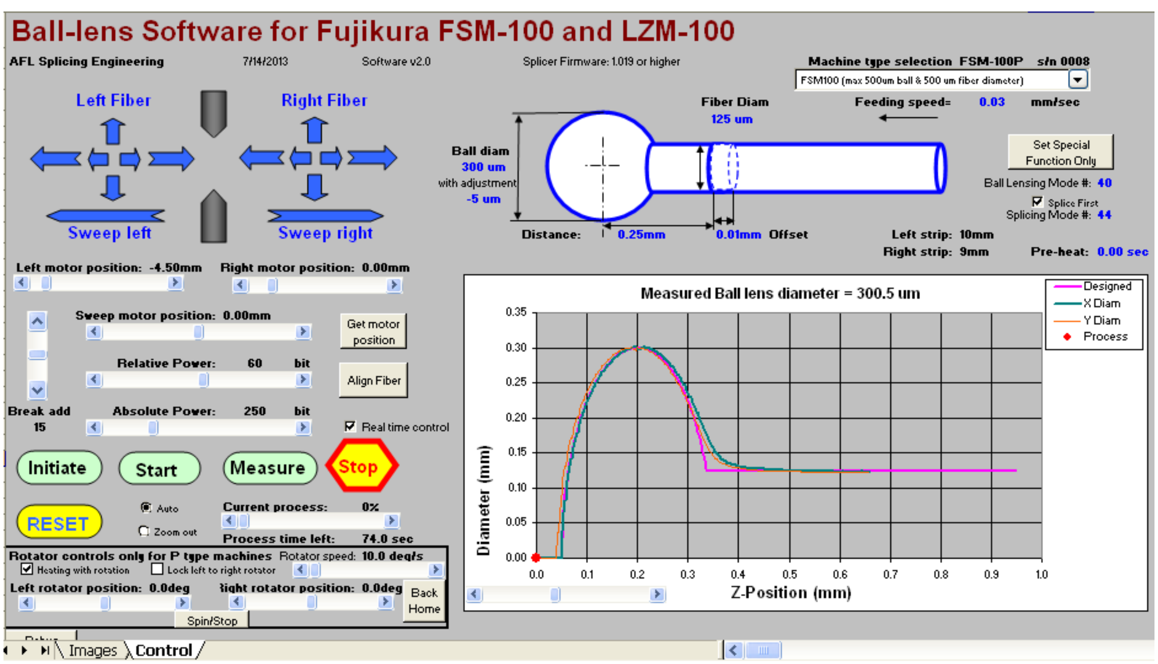


Figure 3.4: Control page and splicer information on the top right

The machine type is automatically set by the ball lens software at the time of file launching. However, if you would like to manually select a different machine type, you can use the drop-down box on the top-right of the GUI. Please be aware that if the selected machine type is not the actual machine type to which you are connected, the motor travel range, the process instruction, and the waning texts will all be incorrect. Your process may not be properly completed.

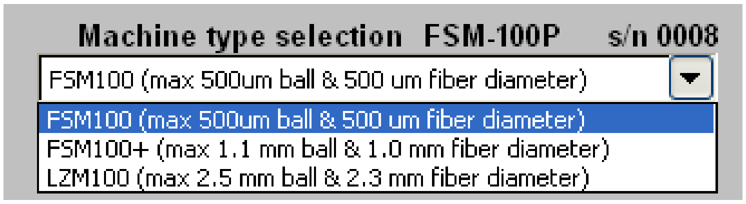


Figure 3.5: Drop-down box for the machine type selection on the top right

Figure 3.6: Common error at the first time launching

Important Note: Sometime the ***Connection error*** in Fig 3.6 is shown at your first time launching, you need only click OK and continue with your work. If you encounter a consistent communication error when you launch the Excel ball lens application (and the splicer is connected and in the "READY" state), it may be necessary to troubleshoot the communications error. It is best to do this using the communications software included on the Fujikura CD ROM that was supplied with your splicer. (This is the software package that enables splicer firmware upgrading from the internet, capture of screen images, and other function.)

Additional Note #1: In order to use this software, you must first completely close Excel. You must not only close the Excel ball lens application, but also any other Excel files that are open on the PC. Otherwise Excel and the Fujikura software will have a conflict competing for use of the USB port. After closing Excel, launch the Fujikura communications software. Confirm that communications has been established by using some of the functionality of the Fujikura communications software such as starting live video, clicking on "X/Y" to ensure that the X/Y command changes the display image on the splicer, confirming that clicking "RESET" on the Fujikura software resets the splicer, etc. If the Fujikura communications software successfully communicates with the splicer, completely close that software (to avoid a communications conflict), and re-open the Excel ball lens software and try again. If the Fujikura communications software does not properly communicate with the splicer, consult with your AFL or Fujikura service support representative.

Additional Note #2: When using the Excel ball lens software, other applications that might compete with the Excel ball lens software for use of the USB port to communicate with the splicer (such as the Fujikura communications software application) must be closed. However, you may have multiple Excel files open simultaneously.

4. Making A Ball-lens

The ball-lens can be made either automatically or manually. To achieve a repeatable ball-lens for production line applications, it is recommended that the automatic process should be used. However, if you would like to make a ball-lens with a special shape, such as an elongated ball, a tapered ball, etc. the manual mode can be used as a starting process.

4.1. Automatic mode for ball lens making

With the automated ball-lensing process, you normally need to complete the following steps: (1) parameter input, (2) machine initiation, (3) starting ball-lens process, and (4) ball-lens geometry measurement.

For making a desired ball lens, you need to determine and input the ball length geometry, heating power, rotation speed, feeding speed, the mode number selection in the splicer that will be utilized for making the ball lens, the mode number which contains the splicing parameters (if a splice will be performed prior to making the ball lens), etc. In the control page, all the numbers with blue color are editable by operators.

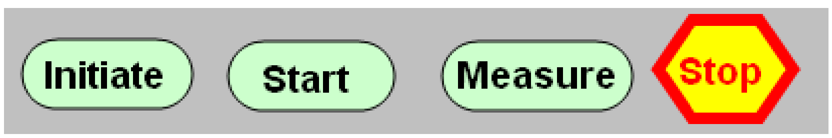


Figure 4.1. Control buttons for the automated ball-lensing process

At the moment when the ***Initiate*** button is clicked, all your input and selected parameters will be sent to the selected mode of the splicer. The splicing parameters previously contained in the mode will be overwritten. The *ZR* and *ZL* motors as well as the *Va* and *Vb* motors will move to the initial positions based on your input parameters and be properly positioned to be ready to accept fiber loading. If any of the ***Pause*** functions are ***ON***, you will be required to turn them all ***OFF***.

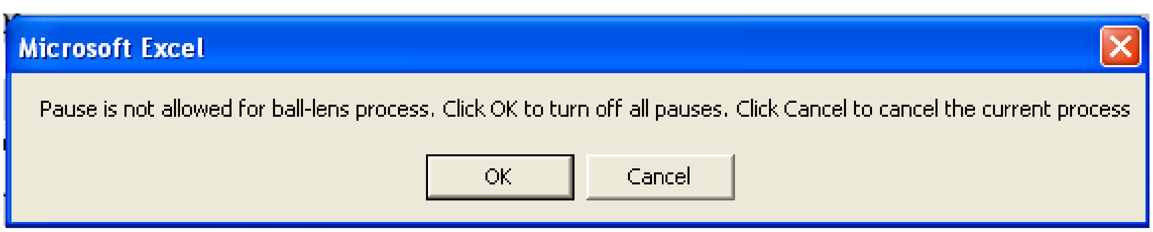
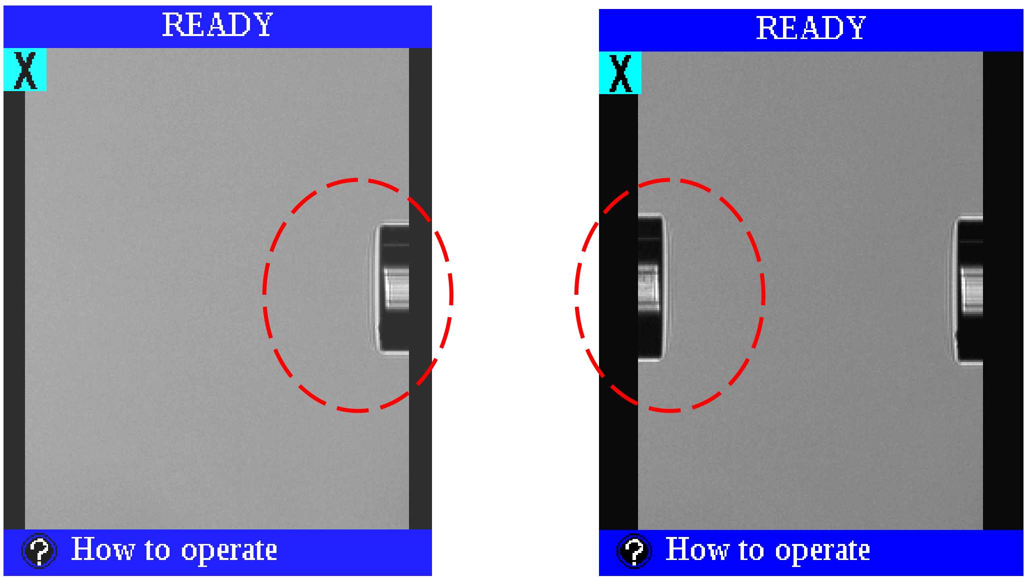


Figure 4.2. Turning *Pause* to *OFF* for ball-lens process

Important notes for fiber loading: please keep in mind that for making a ball lens, the blue v-grooves may be far away from the center position compared to ordinary splicing. You need to manually adjust the fiber strip and cleave length in the fiber holder to keep the fiber ends as close to the screen edge as possible. It is best if you can see the cleaved fiber end on the edge of screen as shown below in **Figure 4.3**. If you do not pay attention to the initial fiber starting position, the fiber and V-groove may be automatically moved forward to a ***GAP*** position that is too close to the heating area at the center of the screen. This may either cause a lack of space for the motor travel, or in some cases it may even burn the fiber clamps since one of the V-grooves and fiber clamps may be moved into the heating area. Please pay close attention to this note, since the machine does not know your actual strip length. If the clamps are burned, please contact AFL/Fujikura to purchase replacement parts.



(a) Single fiber ball lensing **(b) Dual fiber ball lensing**

Figure 4.3. Best fiber loading position for ball-lensing. The red dashed-line circles indicate the critical location for ball-lens processing.

After loading the fiber, you can either click the ***Start*** button on the PC screen or press the ***SET*** button on the splicer to start the ball-lens processing. Since all the ball-lensing parameters are already transferred to the splicer, you can repeat the same ball-lensing process on the production line with the splicer without connection of a PC.

<u>Important note for ball-lensing with rotation and splicing</u>: During this process, since the right fiber holder moves backward right after splicing in order to reach the proper breaking point of the left fiber, the right fiber will bowed between the right-side rotator and right-side fiber holder. As soon as the rotator starts rotation for the ball lensing step, the bowed fiber will be snapped and broken by the rotator. Therefore it is important that the right fiber should be pulled slightly to the right after the splicing to keep it straight (and unbowed) inside the rotator. If the ***Start*** button is selected at the time you are running this application, a warning message will be shown on the screen (as shown below) to remind you to pull back on the fiber. You can turn the warning message ***OFF*** for the next operation by clicking ***Yes***.

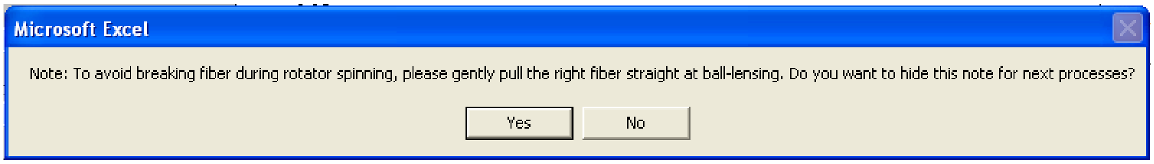


Figure 4.4. Warning for ball-lensing with rotation and splicing.

When the ball-lensing process is completed, by clicking the ***Measure*** button you can obtain the ball lens measured diameter, shape displayed on the screen, and images saved to the folder where the ball-lens program is located.

During any process described above, if you would like to stop the process immediately, the ***Stop*** button can be clicked. This button will stop all the motors at the current position as well as turning off the heating power in the splicer. It also stops the Excel program process. If the process is stopped, it cannot be resumed. If you would like to start another ball-lens process, you need to either click the ***Initiate*** button on PC screen or press the ***RESET*** button on the splicer.

In the following sections, the application and functions of all parameters and settings will be described in detail.

4.1.1 Ball lens geometry

In the following example, a ball lens of 400 µm diameter is going to be made with a coreless fiber with 125 µm cladding diameter. In this example, the coreless fiber is spliced to 125 µm diameter SMF28 fiber. The distance between the splice point and the ball center is set to be 250 µm. This process therefore results in a pure silica ball lens on the end of a single mode fiber.

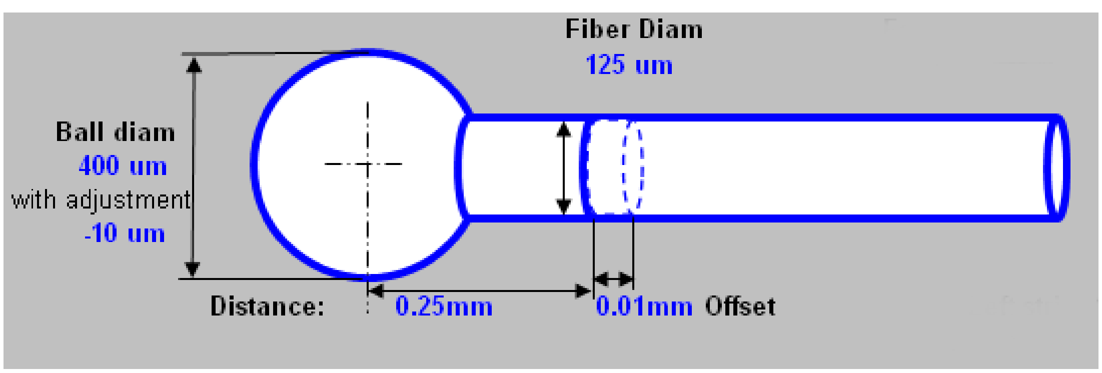


Figure 4.5. A 400 µm ball lens is to be made with spliced 125 µm diameter fibers. The splice point is set to be 250 µm from the ball center.

The 125 µm diameter is typically a fiber diameter specification value, however the actual fiber diameter may vary from that specification by a few microns. This difference will cause a ball lens diameter deviation. After performing a few tests, you can easily identify a diameter adjustment value, either positive or negative, to help you to reach the desired ball lens diameter. In a similar way, a fine adjustment of the distance between the ball-center to the splice point can by input by using the ***Offset*** value.

If the ball lens is to be made with a single fiber, the ***Splice First*** check-box should be unchecked. And the ***Distance*** and ***Offset*** values will automatically become blank.

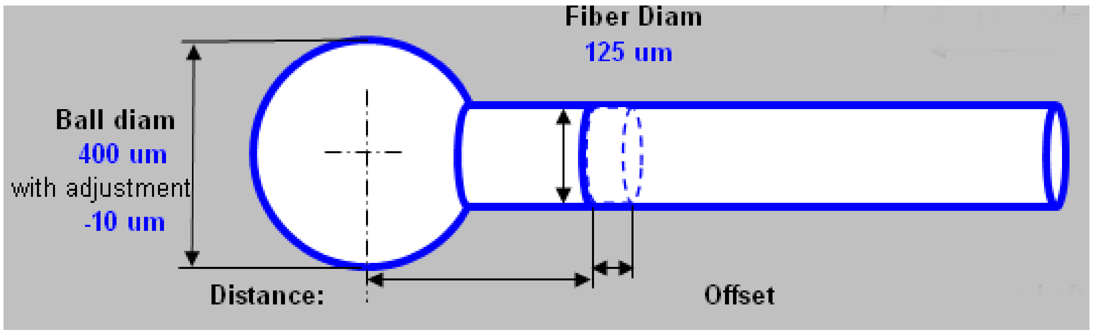


Figure 4.6. The *Distance* and *Offset* values will become blank automatically if the *Splice First* check-box is unchecked.

4.1.2 Feeding speed

For making a proper ball lens, you need to input a ***Feeding Speed*** for the process. The acceptable range of the speed is from 0.01 mm/sec to 1 mm/sec. If a value outside the range is input, the value will show on the screen in a red font color, instead of blue. The lower the speed, the higher quality of the ball-lens that can be made. But the slower speed requires longer processing time. Optimize the speed to balance the ball quality and the production time to meet the needs of your application.

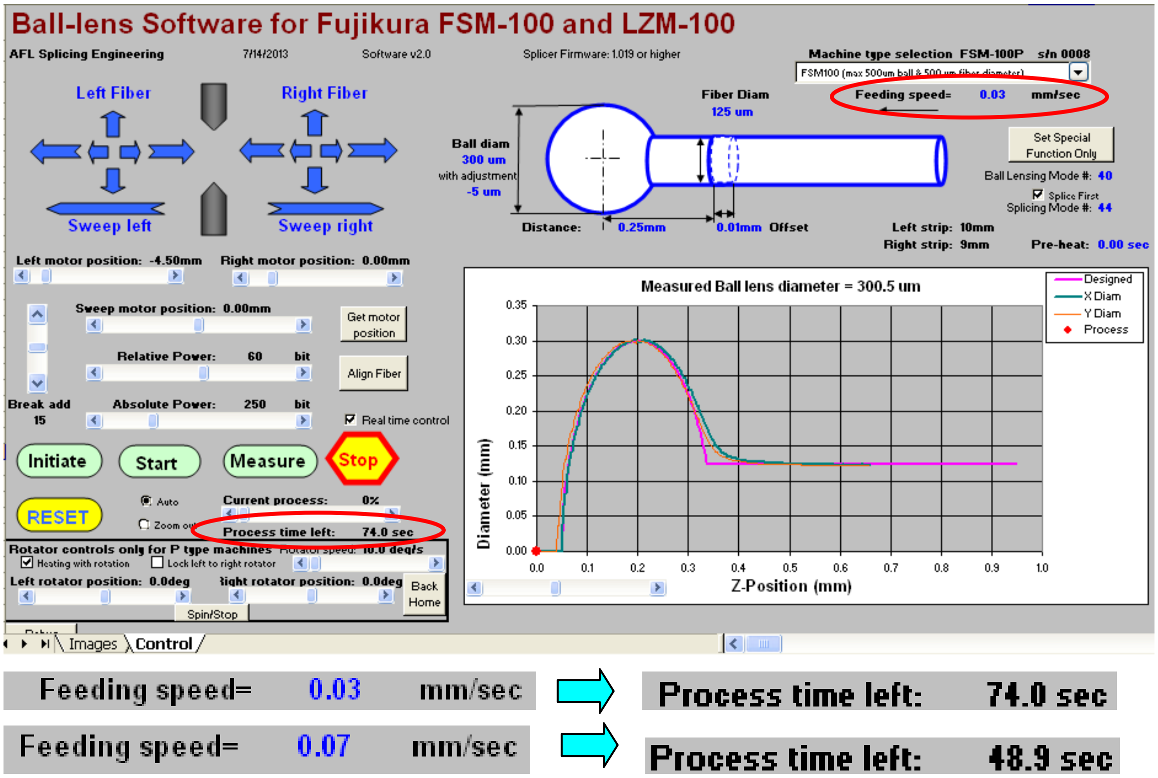


Figure 4.7. Different feeding speed will cause different process time and different ball quality.

4.1.3 Mode number for ball-lensing

The FSM-100 and LZM-100 splicers have 300 user programmable modes that may be edited for a variety of splicing or ball-lensing programs. You can use any mode number for your ball-lensing procedure. However, it may be a good idea to select an empty mode, since all the parameters contained by this mode number will be permanently overwritten when the ***Initiate*** button or ***Set Special Function Only*** button is clicked. Right before the overwriting, a final warning will be shown for your confirmation, as shown below.

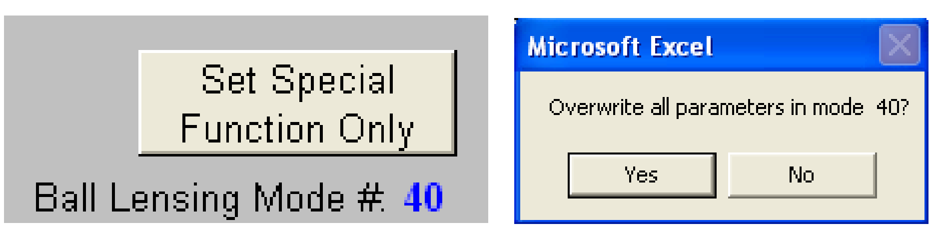


Figure 4.8. Splicer mode selection for ball-lensing and warning message for parameter overwrite

When the ***Initiate*** button is clicked, in addition to the parameter transferring to the splicer from the ball lens PC GUI, the selected mode will be activated in the splicer. If you only want to transfer the parameters to the splicer, you can click the button ***Set Special Function Only***.

4.1.4 Mode number for splicing

A ball lens can be made with either a single fiber (without splicing) or using two fibers after splicing. A check-box ***Splice First*** in the control page is used for this selection. When this check-box is checked, you need to provide a mode number which contains the appropriate splicing parameters for fiber combination you are going to splice (in addition to selecting a mode number for the ball lens operation). It is a good idea to make a splice trial with the splice mode first to make sure the splicing parameters are valid and work well for your fiber combination. Please also notice that the fiber to be kept with the ball-lens attached is always on right side. For ball lens operations without splicing, you must load the single fiber in the proper position on the right side of the splicer. For splicing first followed by creating the ball lens, the fiber that will provide the material to form the ball lens is loaded in the left side of the splicer, and the fiber to which the ball lens will be attached is loaded on the right side of the splicer.

Figure 4.9. *Splice First* check-box and the splicing mode number to provide splicing parameter information for the ball-lensing process. In the example above, mode 40 will be used to make the ball lens. The parameters in mode 44 will be copied to mode 40 for the splicing operation that is performed prior to ball lens making.

For splicing parameters in the splicing mode, please make sure to use the ***Special Arc Calibration*** for FSM-100 splicers. Please also keep in mind that the electrode gap and electrode height for splicing in this mode will also be used for ball-lensing. So, please choose a larger electrode gap value and zero electrode height value when possible, since the large electrode gap will provide enough heat power for ball lensing. For example, for splicing 125 µm SMF28, a 1 mm electrode gap is normally used. But for achieving a 400 µm ball, a 2.2 mm electrode gap should be used. So, in the mode which providing the splicing parameters for ball lensing (mode 44 in the Figure above), 2.2 mm electrode gap should be used for splicing. For the LZM-100, those electrode-related parameters will make no difference since there are no electrodes in the CO_2 laser splicer. Moreover, the ***Standard Power calibration*** is good for LZM-100.

4.1.5 Power calibration and power setting for ball-lensing

To determine the proper heating power to use for ball-lens generation, a power calibration should be made in advance. For either a single fiber ball-lensing operation (without splicing) or a dual fiber ball-lensing operation (with splice), you should always use the fiber which you want to keep as the pigtail to run a special arc calibration at electrode gap 2.2 mm and 0 electrode height for the FSM-100. For the LZM-100, use the standard lase calibration.

The power used for ball-lensing is normally 30% higher than that for splicing. The best power level to be used is fiber type dependent and therefore the power parameters need to be optimized. As shown in the following figure, 3 parameters can be adjusted for heating power. The ***Absolute Power*** should be set to be the same value as the ***Power Calibration*** value, which can be read from the splicer. The ***Relative Power*** is the additional power required for ball-lensing. It can be a positive or negative value. The ***Break Add*** power is used only for the additional power to break the fiber when fibers are spliced before ball-lensing. (***NOTE:*** In this case, just after splicing, the spliced fibers are moved in unison to the right a distance calculated by the ball lens software, and an additional arc or lase is used at the ***Break Add*** power to heat the left fiber at a distance away from the splice point. This is done while the fibers are pulled outwards, so the left fiber will therefore be broken apart at a distance from the splice point. This operation results in the correct amount of remaining left fiber type to generate the correct size ball lens, at the correct distance from the splice point.)

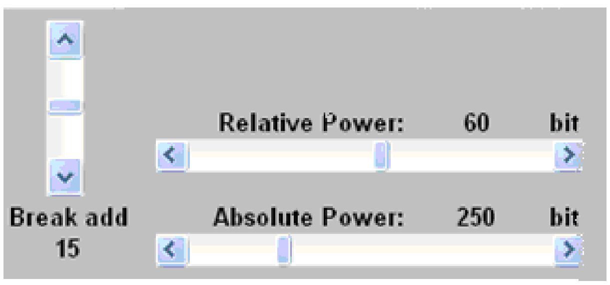


Figure 4.10. Power control bars for ball-lensing

To change the powers in the power bars, you need to either drag the cursor in the bar for a rough tune, or click the side arrows of the bar to fine tune (bit-by-bit). You cannot edit the numbers directly (which are in black font color).

4.1.6 Rotation parameters

The rotator control settings are only functional for splicers which have one or two rotators installed, such as FSM-100P, FSM-100P+, and LZM-100 with at least a rotator option on the right side of the machine. If no rotator is found on your machine, a message "No rotator found for this function" will be displayed. If you are sure there is rotator with your splicer, please close the Excel file and reopen it again to let software re-communicate with your splicer.

For creating a ball lens with a large ball diameter to fiber diameter ratio, rotating the fiber during the ball-lensing can effectively reduce the effect of gravity and keep the offset between the ball center and fiber center negligible or very small. Generally speaking, a higher rotation speed will yield a lower value of the offset. The maximum rotation speed is 50 deg/sec for the FSM-100 and 150 deg/sec for LZM-100. The offset of ball lens center relative to fiber axis center is not only related to rotation speed. It is also strongly related to the feeding speed. A feeding speed that is too fast will cause a heating of the neck of the ball lens. This will result in a very large offset between the ball and fiber centers.

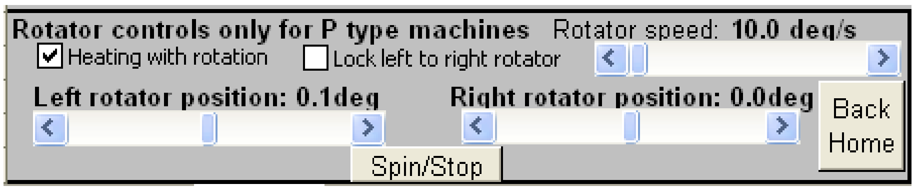


Figure 4.11. Rotator control settings and indicators

To spin the fiber during ball-lensing, the ***Heating with rotation*** check-box needs to be checked. After ball-lensing, the rotator will go back to the home position automatically when the wind protection cover is opened. You can also manually send the rotators to the home position by clicking the button ***Back Home***.

4.1.7 Other parameters and buttons

Get motor position: By clicking this button, the current ZL, ZR, Sweep, and theta motor positions will be shown by the corresponding indicators on the screen. These indicator bars can also be used to move the related motors by dragging the scroll.

Figure 4.12. Controls for reading motor positions, aligning fibers, and real-time ball diameter control (RTC) for single fiber ball-lensing

Align Fiber: By clicking this button, the fibers at the gap position will be aligned using the alignment method selected in the current mode of splicer.

Real Time Control: By checking this check-box, the ball diameter will be measured at the end of the ball-lensing process. If the ball lens is smaller than the target, an increment of ball-lensing process will be repeated up to 10 times and the ball lens will be re-measured until the target is reached. By reducing the **Ball diameter** adjustment value, you can ensure that the initial ball lens diameter at the end of the ball-lensing process is always slightly smaller than the target diameter. Then the Real Time Control can be used to automatically increment and approach the target size. This process will require a slightly longer total process time, but you can-obtain better geometry accuracy and repeatability.

Figure 4.13. Controls for resetting splicer, image field of view, and process indicator

RESET: By clicking this button, the splicer will be reset to its home position immediately. It has the same function as pressing the ***RESET*** button on the splicer.

Auto or Zoom out: By the selection, the fibers image will be shown in a different field of view during measurement.

Indicator for Current process: This indicator shows the estimated process percentage that has been completed. The estimated remaining process time is also displayed.

Pre-heat: This value can be positive or 0. If it is positive, it will provide extra fiber heating time (selected in seconds or fractions of seconds) before the *ZR* motor feeds the fiber forward for ball-lensing. This pre-heating may be necessary for fibers with very large diameter (> 1.0 mm). If it is zero, the preheating is disabled.

4.1.8 Auto mode example: Coreless ball lens spliced to 80 µm fiber

This application example illustrates setup and use of the ball lens auto mode. In this example, an 80 µm single mode fiber is spliced to a 125 µm coreless fiber. A 350 µm ball lens is generated with the coreless fiber. In this case, the splice point should is just to the right edge of the ball lens. For the initial splicing of the 125 µm coreless fiber to the 80 µm single mode fiber, the standard 80 µm fiber splicing mode can be used, which can found in the splicer database and loaded into mode 41. In the case of performing this operation with the FSM-100, a few splice recipe parameter modifications should be made: Change the electrode gap from 1 mm to 2.2 mm, turn auto stuffing ***OFF***, increase the pre-fuse power by 30 bits, and change the left fiber diameter 80 to 125 microns for the coreless fiber. (Parameter adjustments for the LZM-100 80 µm program are similar, but with no need to set electrode gap.) Perform a few splices to check the splice result, and tweak the splicing parameters further if required.

For the ball lensing parameters (as shown in the figure below) it is necessary to set the starting fiber diameter to 125 µm since the coreless 125 µm fiber will be used to generate the ball lens. Also, considering that the splice point of the 80 µm to 125 µm fiber will have a tapered diameter transition, it is necessary to set a slightly larger value for the distance from the ball center to the splice point.

Parameter settings and ball lens results are shown in the Figures 4.14 and 4.15.

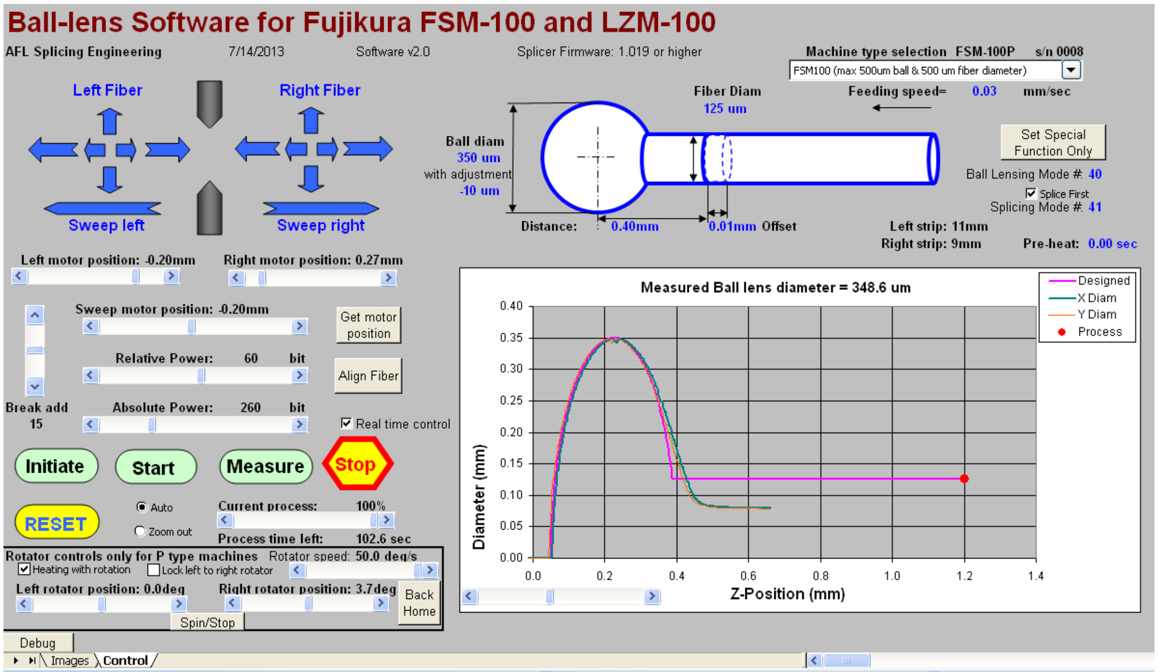
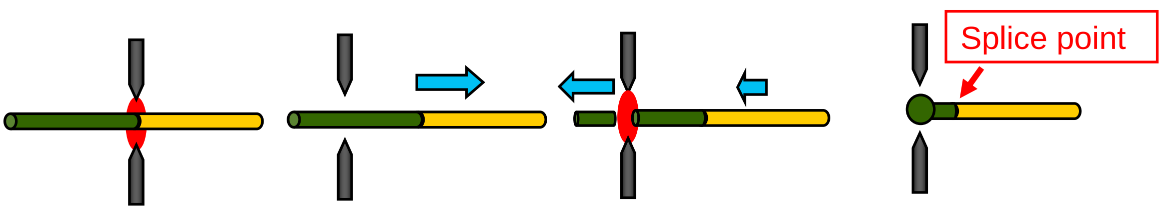
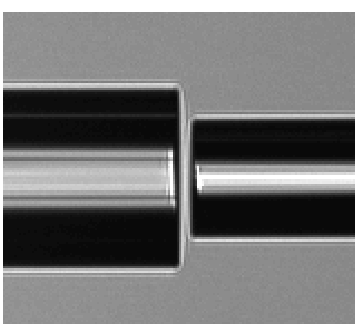


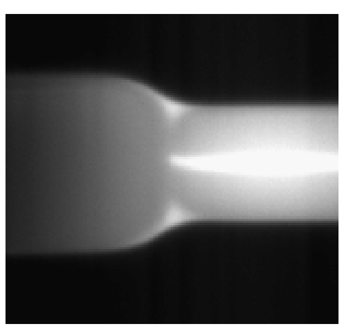
Figure 4.14. Controls parameters for a 350 µm ball lens with 125 µm coreless fiber spliced to 80 µm single mode fiber using FSM-100P



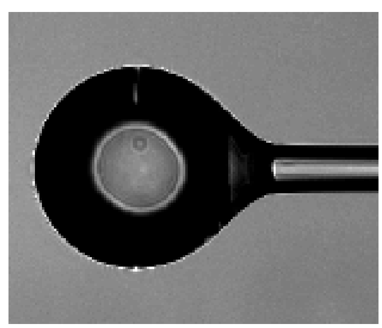
(a) Illustration for automated process of splicing, breaking, and ball-lensing



(b) Before splicing



(c) During splicing



(d) Final ball-lens

Figure 4.15. Process and results are shown for a 350 µm ball lens with 125 µm coreless fiber spliced to 80 µm single mode fiber using the FSM-100P splicer. Total process time is 96 seconds with a measured ball diameter of 348.6 µm.

4.2. Manual mode for ball lens making

The automatic mode can repeat the same process in a well controlled manner to achieve consistency and higher yield for production applications. However, the automatic mode can only make conventional ball lenses, which have a spherical shape and with a diameter larger than the original fiber diameters. If a special ball lens is to be made, such as an elongated ball, a tapered ball, etc. as shown in Sec 4.2.4, a manual ball-lensing operation will be required.

4.2.1 Moving the motors

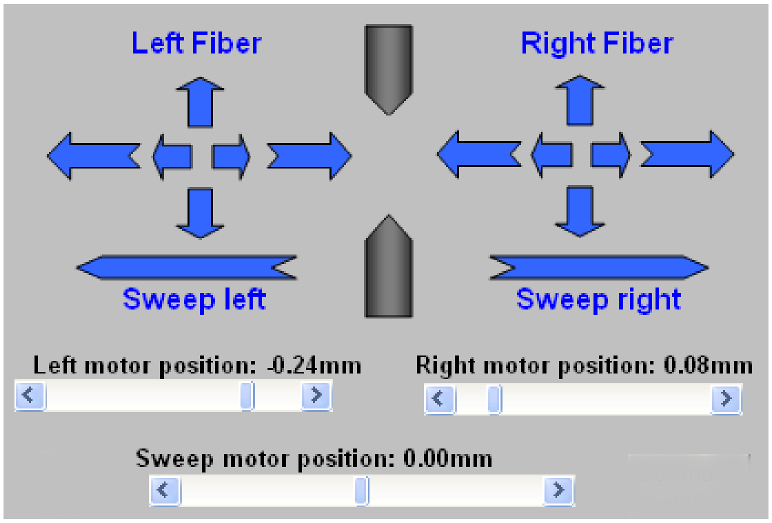
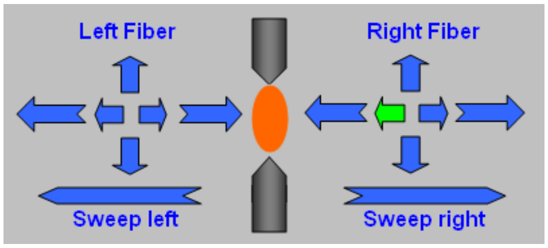
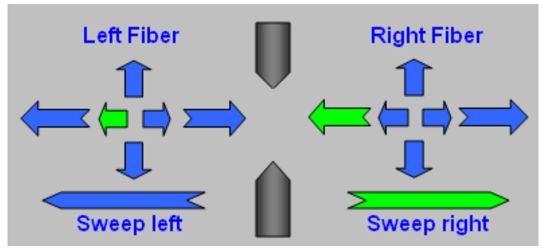


Figure 4.16. Controls for motors and heat (arc discharge or CO_2 lase)

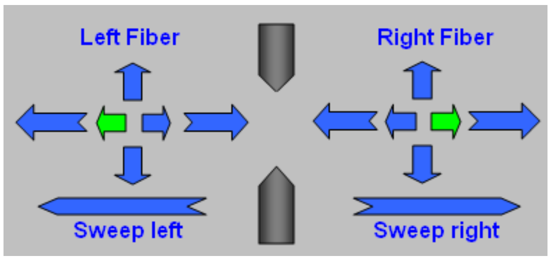
The blue arrows in the control page control the fiber position. When you click on one of them, the corresponding motor will move and that arrow becomes green. To stop the motor movement, click the green arrow (it will turn back to blue when the motor stops). If the black electrodes and the area between them are clicked, the arc (for FSM-100) or the CO_2 lasing (for LZM-100) will be initiated. You can stop the discharge (or lase) by clicking it again. Several motors and the arc (or lase) can be running at the same time. If you would like to stop all motors and the heating at the same time, you can click the red ***STOP*** button.



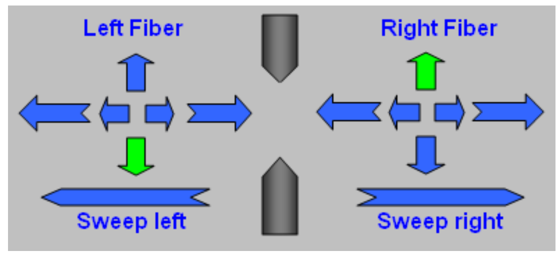
(a) Feeding right fiber to heat



(b) ZL slowly, ZR quickly, and sweep



(c) Slowly pull fiber apart



(d) Left fiber goes up and right down

Figure 4.17. Examples of different motor moving control

The motor location indicator bars can also be used to move the corresponding motors by dragging the scroll or click and hold the arrows on the sides of the bars. The indicator bars can also show you the current motor location as discussed in Sec. 4.1.7.

4.2.2 Motor moving range

Depending on the machine type you are using, the motor moving range is different. The following table shows the available moving range of the FSM-100 and LZM-100 splicer family.

Machine	ZL	ZR	Sweep	Heat Power	Rotator speed
FSM-100	5 mm	5 mm	+/- 5 mm	180 – 500 bit	50 deg/sec
FSM-100+	18 mm	18 mm	+/- 18 mm	180 – 800 bit	50 deg/sec
LZM-100	150 mm	150 mm	+/- 150 mm	1 – 1000 bit	150 deg/sec

Table 4.1. Available range of different machine types

If a motor reaches its moving limit, it will stop even if the arrow on the screen is still green. On certain occasions the yellow warning message "***Motor overrun***" will blink on the splicer display.

Due to the motor range limitations, if you want to make a ball lens exceeding the capacity of the machine type, you will also see a warning during your ball lens design. For example, if you would like to make a ball lens of 500 µm diameter with 125 µm cladding fiber using FSM-100, you will see the blue/black number become red because the required feeding length is 7 mm, which exceeds the FSM-100 ZR range of 5 mm.

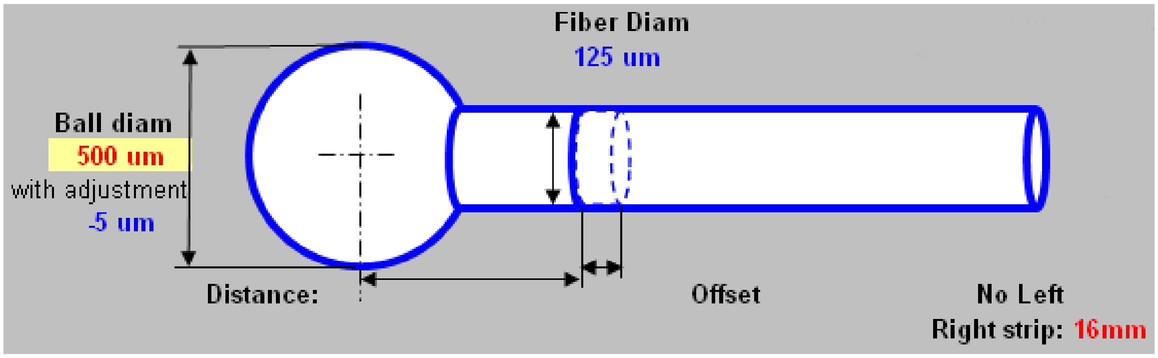


Figure 4.18. The red numbers indicate that 500 µm ball with 125 µm fiber cladding exceeds the range of FSM-100 since the ZR motor cannot travel far enough for the required fiber feeding. In this case, either the ball lens size needs to be reduced, the fiber size needs to increased, or a more powerful machine type (with longer Z-motor feeding travel) should be selected to meet requirements for the desired ball lens diameter.

Similar to the example above, if an input value is out of the capability range, the blue number will become red. The red numbers indicate a warning concerning your input parameters. You may need to reconfigure your design. If you continue to run the process with the red warnings, you are very likely to achieve a failed operation.

4.2.3 Rotator control and spin

The ball-lens process often requires spinning to overcome gravity, for both automatic mode and manual mode. In auto mode, the spin function has already been designed in the software if the ***Heating with rotation*** is checked. But in the manual mode, you need to click the ***Spin/Stop*** button prior to clicking the heating buttons. The rotators will be stopped if the ***Spin/Stop*** button is clicked again during rotation. If the ***Lock left to right rotator*** is not checked, the ***Spin/Stop*** button will only control the right-side rotator.

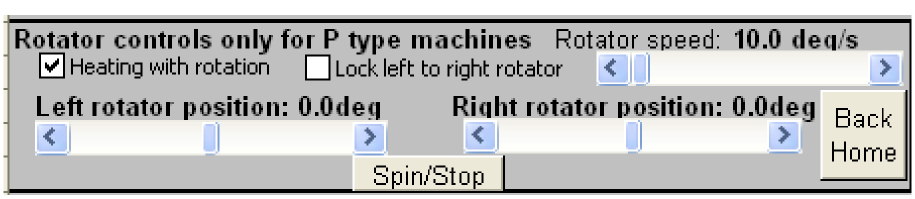


Figure 4.19. The rotator controls and spin button for manual ball-lensing

4.2.4 Examples of manually made lens

Some typical ball lens examples made with manual mode are shown below. In the examples, we can see the radius of the lens tip varies in a large range, from millimeters (convex lens) to a few microns (axicon). The different tip radius enables generating lenses for a variety of different applications.

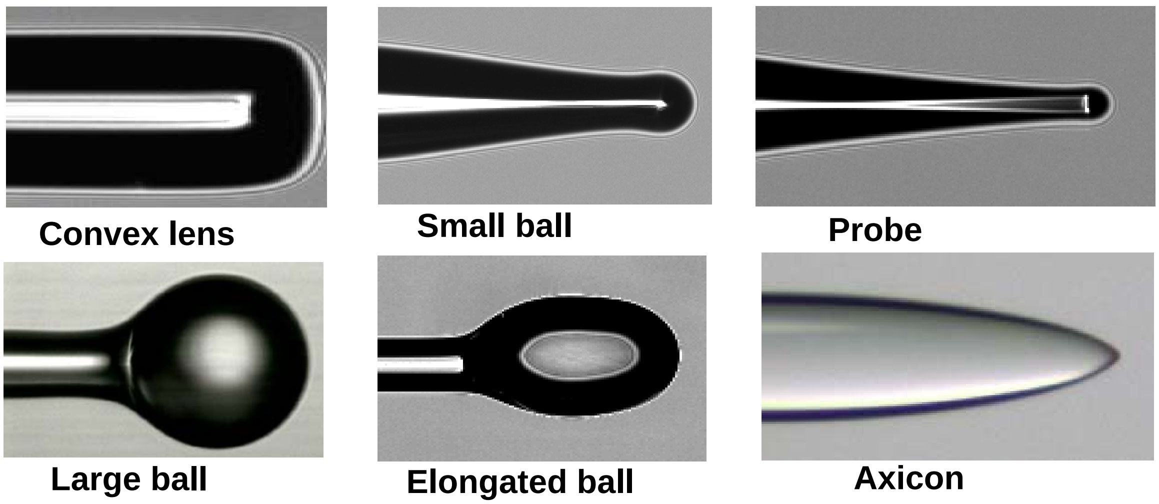


Figure 4.20. Examples of various lenses made using the manual mode are shown. The radius of lens tips can vary from a few microns to millimeters.

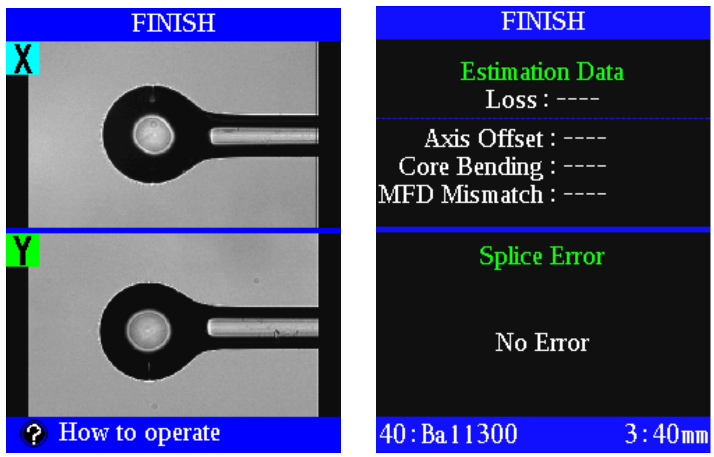
The manual operation is more of a development process method rather than a production method. Although you can create many different ball lens shapes, it may be difficult to repeat and achieve consistency. AFL may be able to provide contract engineering services to help develop enhanced software or process development and optimization to create a consistent desired lens shape with PC control for these special applications.

5. Ball-lens measurement

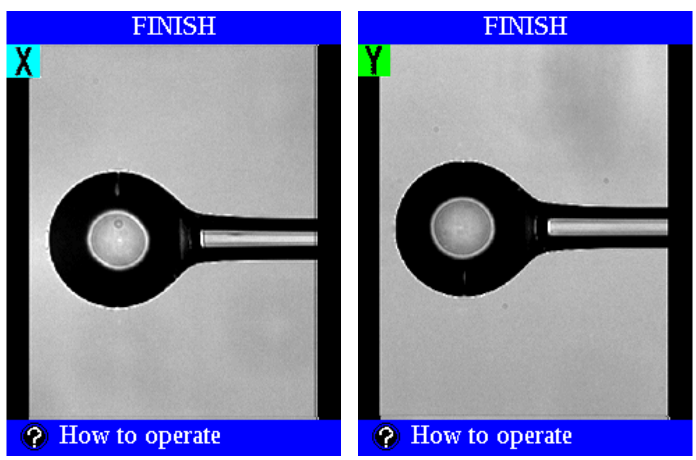
After making a ball-lens, it is very important to make an accurate measurement of diameter and shape. The ball lens images should be easily analyzed and archived. This Ball-Lens software provides all of these functionalities.

5.1 Measurement procedure

After the ball-lensing process, the splicer will display the images based on your Splicer Settings. As examples, you may see displayed on the screens split images of X and Y view with splice or fiber information, the warm image taken during splicing, the fiber-ends images taken before splicing, the live full images of X and Y view, etc. Some of those images are shown in the charts below. By pressing the ***X/Y*** button repeatedly on the splicer, you should be able to see the full images of X and Y view each on a different display. The ball lens measurement is better performed when these images are shown on the splicer display monitors for valid image analysis (see details in Sec 5.2). In the case you cannot find these images by pressing the ***X/Y*** button, modify the ***Display at Finish*** selections in the ***Splicer Utility Settings*** sub menu.



(a) Split X and Y view images with splice info on the right



(b) Full images of live X and Y view good for ball lens measurement

Figure 5.1. Examples of images shown after ball-lensing process

Important Note: Before clicking the ***Measure*** button on PC screen, please make sure that the splicer is in ***Finish*** mode, i.e., “FINISH” is shown on top of screen. Since the processing time on the PC screen is an estimated value, sometimes the process on the PC may be shown as completed but the actual process in the splicer is not, especially when the ***Real Time Control*** process is running. If you click the ***Measure*** button too early while the actual ball lens process has not been completed, you may see an error message indicating loss of communication on your PC. When this happens, you may need to unplug the USB cable connecting to the splicer and re-plug it to re-establish the USB communication.

After the ***Measure*** button is clicked on the PC, the right fiber holder will move forward to position the ball lens on the screen (within the field of view of the FSM-

100 splicer cameras) to enable a better measurement. If the ball position is not the desired position, you can always click the manual control buttons to move the right fiber a little left or right.

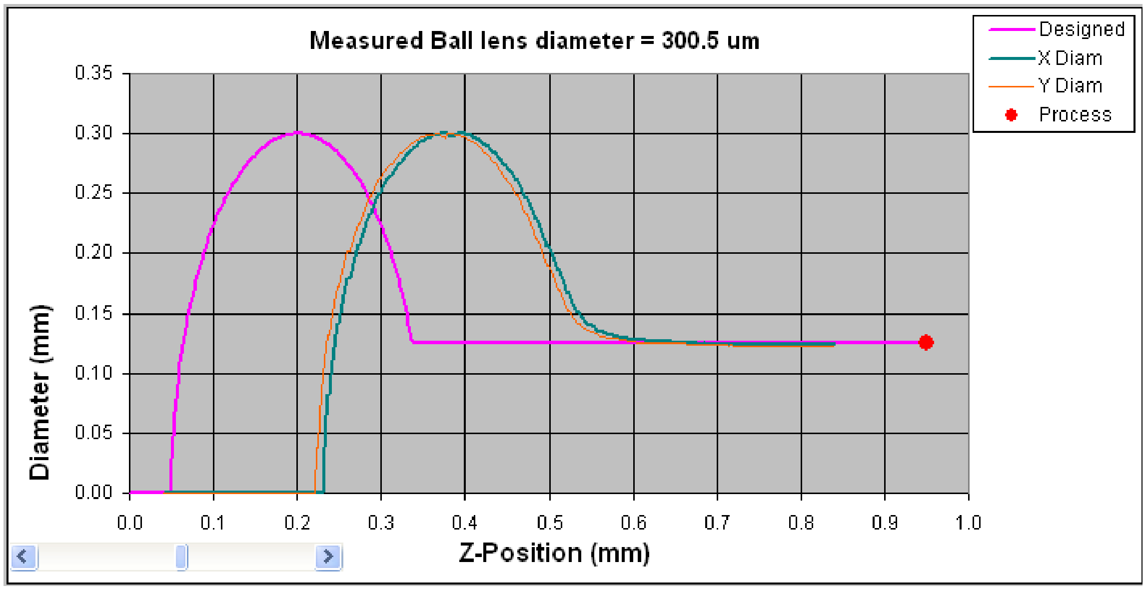


Figure 5.2. Example of measurement for a 300 µm ball lens

In the measurement chart, the pink curve is the designed target. The green and orange curves are measurement from the X and Y view cameras, respectively. The measured ball lens diameter is shown on the top of the picture. In the figure above, the measured curves have an offset in ***Z-position*** due to the ball lens location in the field of view. For a better comparison between the measured and designed curve, you can move the measured curves horizontally by dragging the slide bar left or right on the left bottom of the chart as shown in the chart below.

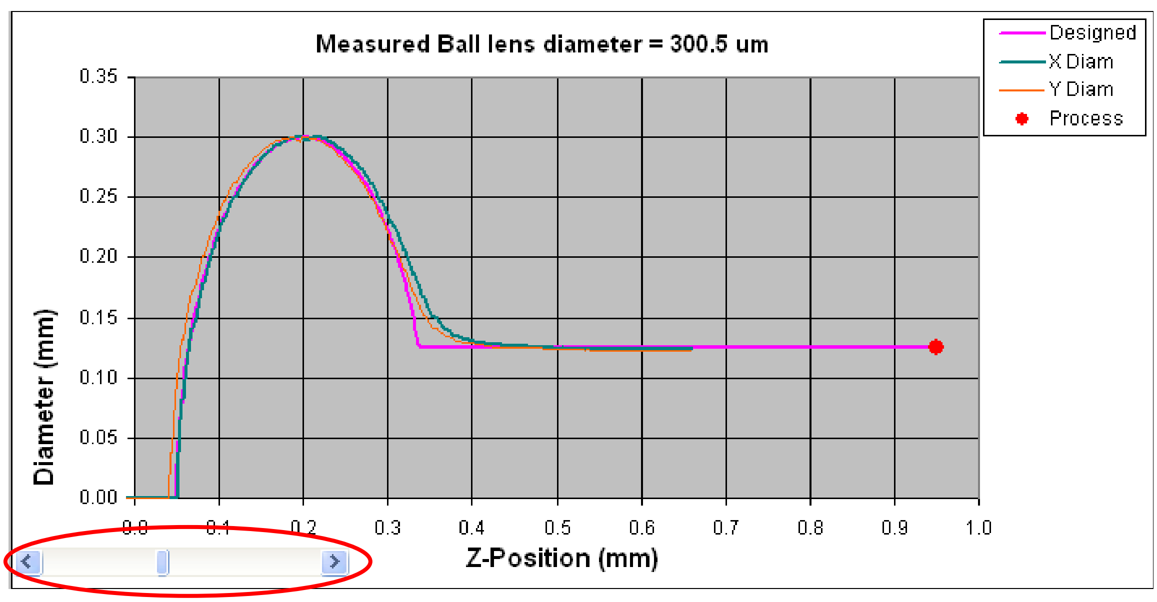


Figure 5.3. Moving the measured curves horizontally by drag the slide bar

5.2 Measuring distance from images

After the measurement, you can see the images in the ***Image Page***.

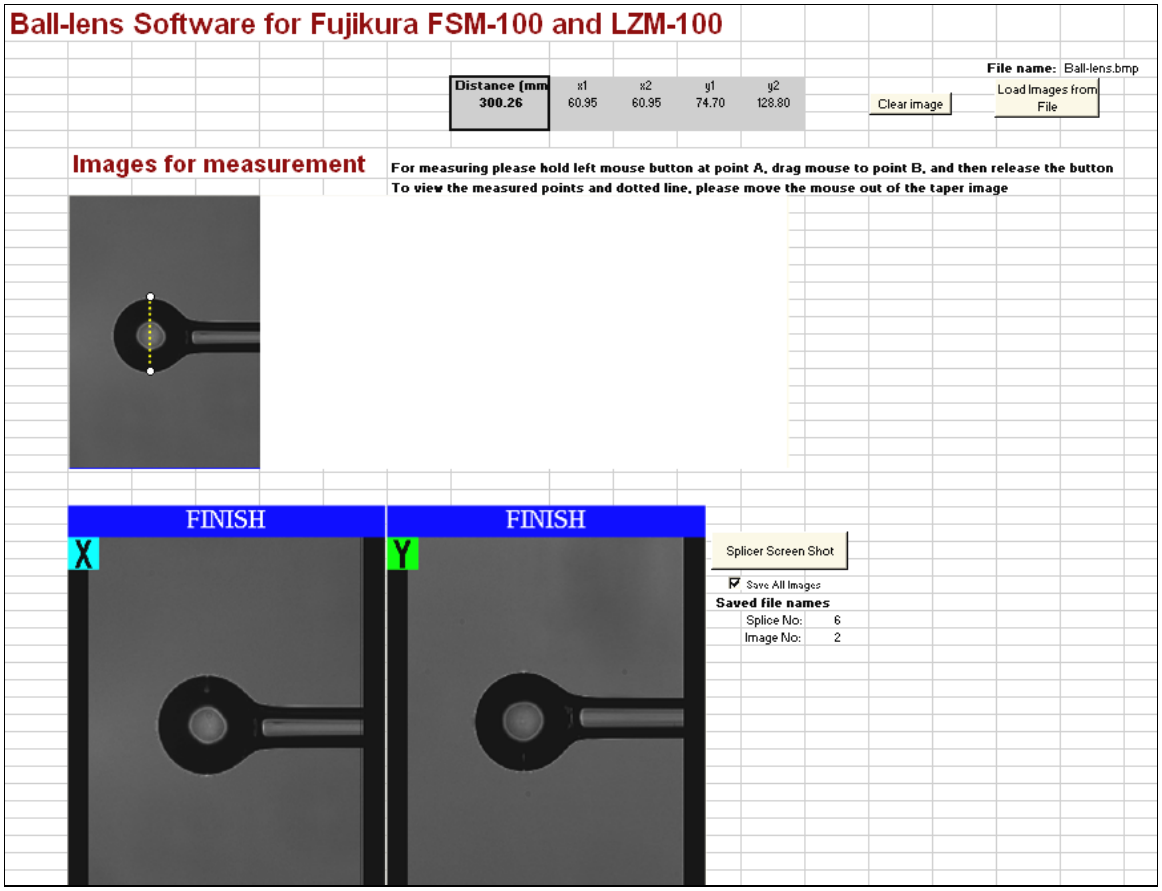


Figure 5.4. Example of the *Image Page*

In the middle of the ***Image Page***, there is an ***Image for Measurement*** area. If the ball lens is extremely large or the splice point is very far away from the ball center, two or more images will be stitched together automatically to show you an overview. The image in this area is measurable. After selection of the image in this area, you can see a thin cross when you move your mouse across the image. Holding down the left mouse button at the point 1 and dragging the mouse to the point 2 then releasing the mouse button, you can read the distance between point 1 and point 2 from the display box on the top of the display. Depending on the image resolution, the measurement accuracy is not as good as the data shown in the ***Control Page***. When the mouse leaves the image area, a yellow dotted line will connect point 1 and 2 to trace your measurement path.

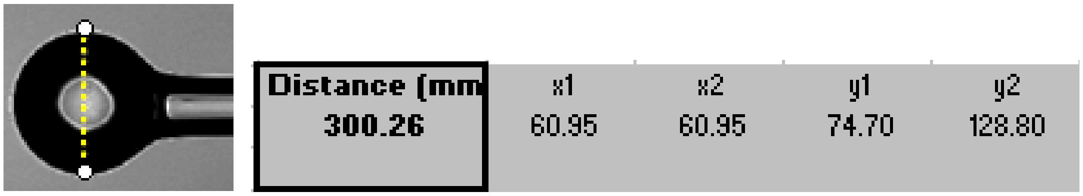


Figure 5.5. Trace of measurement and distance between points 1 and 2

5.3 Image file save and load

If the ***Save All Image*** box is checked, all images taken during the measurement process will be saved with serialized image numbers applied automatically. The images will be saved in the same folder as the Excel program location. The splice number and the image number will be incremented starting from the current number. You can edit the starting numbers as you wish.

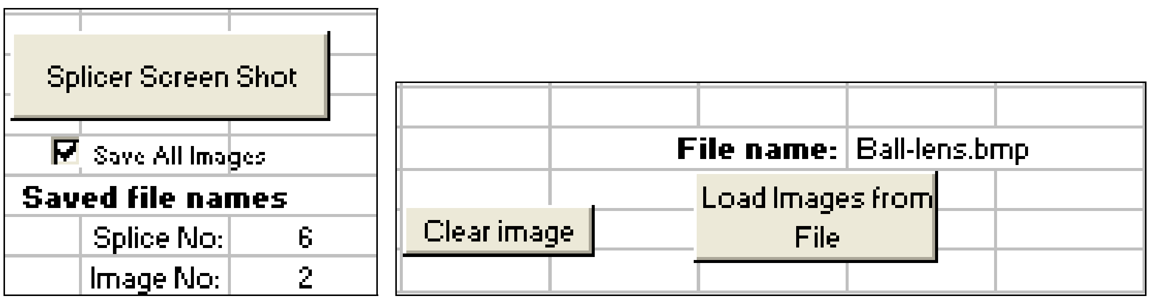


Figure 5.6. Controls for image file save, load, and clear

By clicking the ***Splicer Screen Shot*** button, the current images on the splicer monitors will be taken and saved to the current folder with the current splice and image numbers.

Immediately after the ball lens is measured, the stitched image for distance measurement will also be saved with a constant file name “Ball-lens.bmp”. If you need to keep this file for future use, you need to rename it. Otherwise, this file will be overwritten at the next ball-lens measurement. If you want to load back any of your renamed image files, you can input your file name and then click the ***Load Image from File*** for further distance measurement activities and analysis.

All the images displayed in the ***Image page*** will be removed by clicking ***Clear image*** button. This is not necessary for all the ball lensing and measurement processes. But if you would like to save this Excel file, the file size can be significantly reduced by clearing the images.

6. Summary

AFL's ball-lens software is continuously being reviewed and improved. If you have any suggestions or comments, please contact the AFL OEM sales team or the splicer engineering team.

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