3SAE Large Diameter Splicing (LDS) System

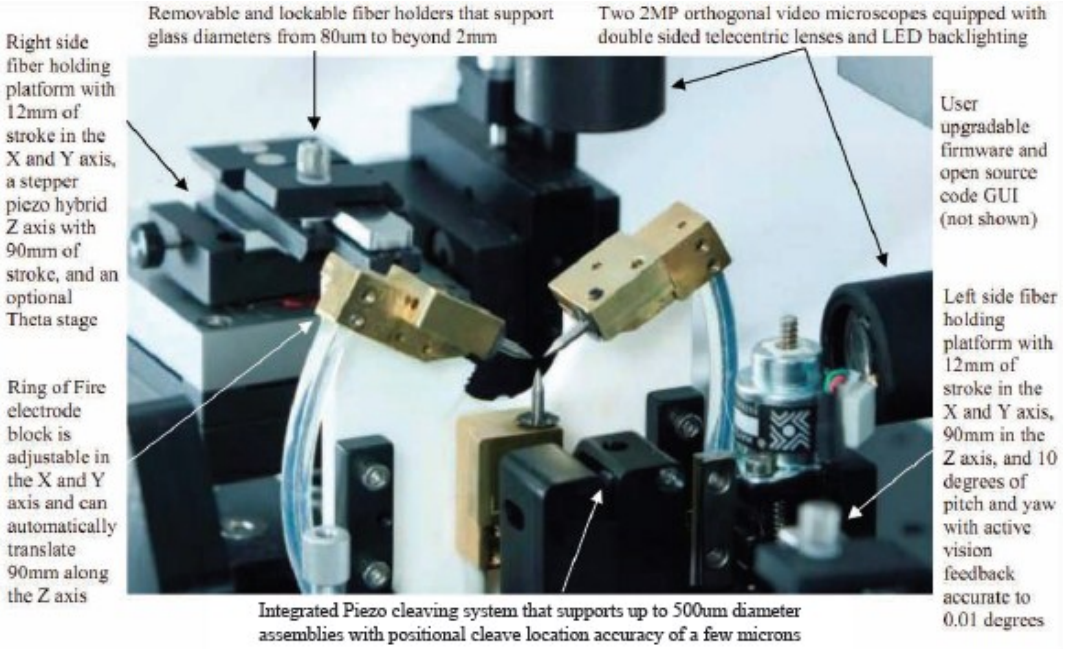
The rapid development of photonic technologies has created the need for sophisticated optical products well outside the "telecom standards". User requirements and specifications for these photonic components are both increasingly diverse and technically challenging; often they cannot be realized due to the limitations in the glass processing and/or ber splicing technology.

Utilizing precision engineering, over 20 years of fiber splicing and glass processing experience, and actual listening to the wants and needs of our customers, 3SAE Technologies has developed the Large Diameter Splicing (LDS) System. Whether the application is splicing of low temperature glass - fibers, tapering, end capping, high power fiber laser component fabrication and assembly (such as mode field adapters, pump combiners and pump/signal combiners), the Large Diameter Splicing (LDS) System provides capabilities that overcome the technical hurdles of current fiber component fabrication processes to meet the most demanding requirements. Designed for reproducibility, precision, and user-friendly operation, the Large Diameter Splicing (LDS) System provides the user a manufacturing approach to optical component product development. Its extreme flexibility will enable customers
to realize current and future glass pro-

3SAE Large Diameter Splicing (LDS) System

Precision mechanical design, coupled with powerful, high contrast optics, absolute control of positional and angular fiber alignment, sets the Large Diameter Splicing (LDS) System apart from competing technologies. An extremely sophisticated image processing software package allows the user to view, in real time, the progress of a fiber splice or optical component fabrication step. The system handles fiber diameters from 50 µm to 2.5 mm, as well as optics such as prisms and lenses, with alignment and fusion of unsurpassed quality.

NorthLab Photonics has the ability to offer large customizations of the Large Diameter Splicing (LDS) System to meet very specific customer requirements. Please inquire about your specific application.

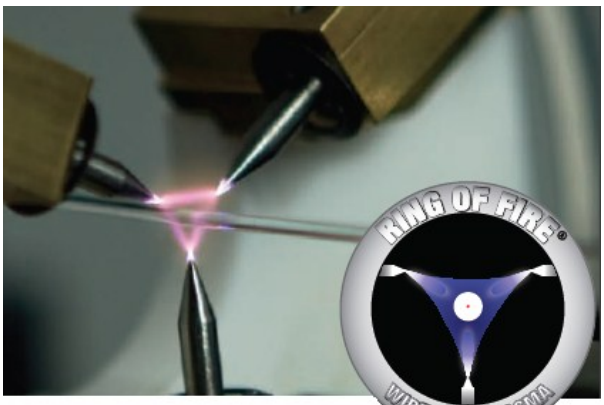


Integrated Piezo cleaving system that supports up to 500um diameter assemblies with positional cleave location accuracy of a few microns

Ring Of Fire® Technology

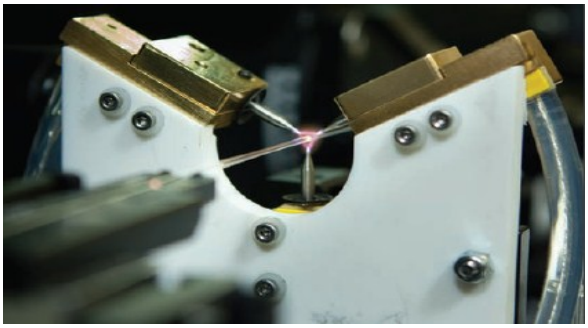
Conventional arc fusion machines utilize a high voltage glow discharge between two electrodes, forming a heat source substantially in the shape of a narrow cylinder perpendicular to the fiber and only a few 10's of microns wide. Such heat sources are ineffective for larger fibers, because of the inability to heat all sides of the - fiber equally.

Flame and filament machines can be optimized to provide substantially circumferential heating, but they also extend the heat zone a relatively large distance along the fiber axis. This is advantageous for some operations, such as Thermally Expanded Core splicing (TEC), but causes substantial limitations in the geometries that can be spliced and formed. For example, these heat sources are poorly suited for splicing a small diameter fiber to a much larger fiber or optical device (end cap, lens, prism). The heat required to raise the larger target to splicing temperatures will typically destroy the smaller fiber.



Ring of Fire® Electrodes

A multi-electrode plasma discharge is advantageous for these operations, as the resulting heat zone is isothermic around the circumference of the fiber, but relatively narrow in the axial direction. This allows for directed heating of larger or higher melting point portions of the assembly. With this system, accurately aligned, mechanically sound splices of small (80-125 µm) fibers to very large (>2 mm) fibers can be performed without difficulty. This is useful for attachment of fibers to end caps or bulk optic lenses.

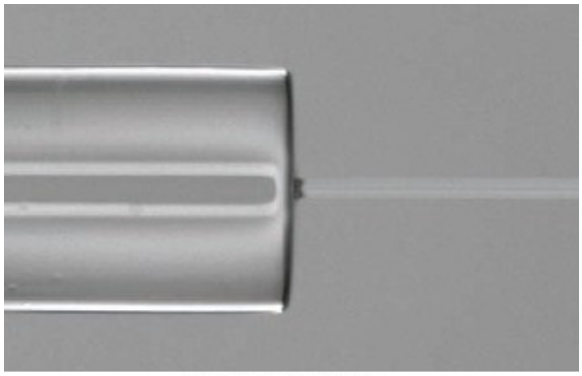


Ring of Fire® Heat Source: Attributes and Capabilities

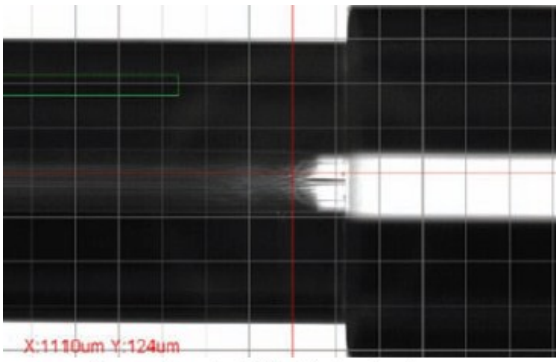
- Three Electrode system design combines proven manufacturing-stable technology with R&D flexibility.
- Isothermal plasma field (triangular two-dimensional plane) up to 100 times larger than standard two-electrode system fields.
- Plasma field monitoring of 300 times per second provides industry leading field-temperature stability (+/- 5 °C)
- Proprietary-alloy electrodes, coupling extended life, high thermal power generation and low maintenance/cost, can be refurbished by user.
- Generates negligible tungsten deposits and requires no specialized gas environment for operation.
- Ideally suited for difficult or developmental applications.
- The high repeatability and stability is ideally suited for manufacturing or large scale pro-

LDS attributes & capabilities (Base package)

- Powerful, positionable Ring of Fire® heat source provides even heating for fiber splicing, fiber end-capping, Photonic Crystal Fiber (PCF) splicing and other applications.
- Splicing of 50 µm – 2.5 mm diameter fibers can all be accomplished using one machine.
- Ability to splice largely dissimilar fiber diameters (with or without fiber shaping) surpasses capabilities of all existing splice technologies.
- "Ionic Ablation" fiber cleaning software provides a secondary cleaning of optical fibers.
- Extremely high splice strengths are achievable without repetitive passes of the plasma field.
- Repeatable and reliable system performance achieved through three automated, easy-to-implement internal calibrations.
- Up to 10 axes of active feedback fiber alignment
- Pitch and yaw alignment (+/- 20° range of motion with 0.01° adjustability).
- "Hot" imaging of x- and y- dimensions, provided simultaneously using two independent, orthogonally mounted cameras, enables user to view fiber processes in real time.
- Automatic scanning software scans fiber diameters pre- and post-splice.
- System capable of splicing end-cap materials with high melting temperatures (sapphire).
- Radius Calculation Tool provides real-time radius values and pass/fail monitoring capability for lenses generated on fiber ends.



2 mm to SMS splice

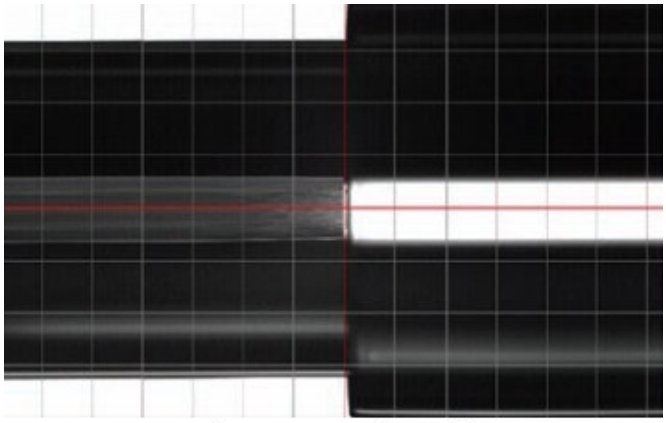


Large diameter PCF with short collapse

- Two-dimensional geometric scanning provides precision heat source balancing by monitoring extremely small dimensional differences in capillary walls or fiber diameters.
- Capability of uniformly collapsing Photonic Crystal Fiber (PCF) to length below 50% the fiber diameter allows low fiber waste cleaving, ultrasonic cleaning (no liquid wicking into air holes) and achievement of excellent splice losses.

LDS attributes & capabilities (Base pacage)

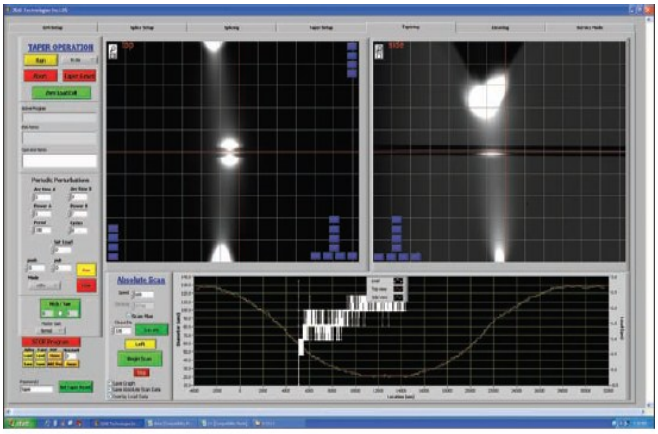
- Many Photonic Crystal Fibers (PCF) can be spliced with no air hole collapse.
- Graphical User Interface (GUI) is intuitive, clearly marked and easy to use; no need to scroll through menus or find functions imbedded within other-functions to change program parameters.
- Real time data and high quality images (before, during and after splice or other process) can be captured and automatically saved to Microsoftcompatible files.
- Piezo-driven flexure stage and software package providing 130 µm of vibration-free z-axis motion with 100 nm resolution.
- Removal of vibrations, hysteresis and backlash allows for absolute fiber alignment during the critical final stage of splicing.



Large diameter PCF with no collapse

LDS System Upgrade Packages

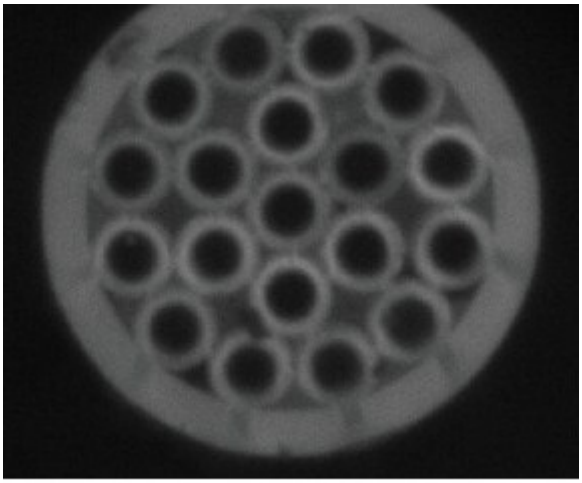
The following upgrade packages target specific needs of the user. They can be offered individually or in groups and can be added to the Large Diameter Splicing (LDS) System at any time.



Large Diameter Splicing (LDS) System Taper GUI

Tapering Package

- Automated software, providing precise motor speed and load cell control, enables reproducible fabrication of low loss and high ratio tapers up to 150 mm length.
- Real time taper scanning function exclusive to the Large Diameter Splicing (LDS) System allows for immediate process feedback by quantifying diameter over length.
- Proprietary Power-Ramp Technology, unique solely to the Large Diameter Splicing (LDS) System, compensates for thermal mass changes along the length of a taper via controlled output-power adjustments to the plasma field during the tapering process.
- Versatile tabbed GUI is easy to use and minimizes visual complexity



19 to 1 pump combiner endface

Bundling Convenience Package *(Tapering Package Required)*

- Package supports capillary-based pump and pump/signal combiners having 2, 3, 4, 7, and 19 input fibers.
- The Bundle Loading System allows easy, high-yield loading of fiber into capillaries (load times generally less than 1 minute).
- Individual fibers can be up to 600 µm in diameter.
- Adjustable fusion level can be applied along length of bundle.
- Integrated imaging camera easily captures end face images of bundle without the need to recalibrate Large Diameter Splicing (LDS) System alignment. (PM Package Required)
- Bundle handling fixtures and tooling included.

LDS System Upgrade Package

Polarization Maintaining (PM) Splicing Package

- Provides rotational accuracy to +/- 0.25° for any PM fiber
- Uses dedicated camera for improved resolution of PM end face images.
- Offers several PM alignment modes for increased flexibility
- Alignment using Image Analysis Software allows independent alignment of PM fibers regardless of fiber shape, fiber diameter, stress element used or fiber type, thus eliminating the need for factory intervention when optimizing splices for new PM fibers.
- Compatible for use with Large Mode Area (LMA) and Photonic Crystal (PC) PM fibers.

End-Cap Splicing Package

- Allows fiber attachment to GRIN lenses, prisms or other shorter-length optical elements that cannot be held using traditional fusion splicer fiber-holding mounts.
- Utilizes a Venturi vacuum system and customized mechanical platform for stable, precise control of minute optical elements during attachment.
- Compatible with real-time scanning software used in the standard Large Diameter Splicing (LDS) System.
- Mechanical platform is easily interchangeable with standard fiber holder platform and offers same degrees of motion.
- Provides unique capability to fuse pre-made end caps having vastly dissimilar diameters to attachment fibers.

Large Diameter Splicing (LDS) System PM GUI

Integrated Piezo LDF Cleaving System Package

- Provides automated in-situ cleaving for production of end caps, tapers, mode-field adapters (MFAs) and fiber combiners up to 500 µm in diameter.
- Cleave location precise to +/- 50 µm
- Real time scanning and image feedback capabilities of cleaver software package provide reproducible reference- and cleave-location control.
- Flat, reproducible cleaves achieved using a diamond-tipped ultrasonic blade with piezo-based frequency/amplitude control as well as a piezo-driven fiber-deflection control mechanism
- Improves process yields of delicate tapers and bundle assemblies by eliminating the awkward processing steps required when using an external cleaver (namely assembly-removal, cleaver-loading and assembly re-loading).

End-Cap Splicing GUI

LDS System Packages and components

LDS-01-0100 - Large Diameter Splicing System Standard Package

The LDS is a Ring of Fire based plasma splicing system with the following default features:

- A Right fiber holding stage with automated X, Y, and Z alignment and manual pitch and yaw alignment.
- A Left fiber holding stage with manual X and Y alignment, and auto Z fiber alignment.
- The X axis has 12 mm of stroke with a 50 nm theoretical resolution.
- The Y axis has 12 mm of stroke with a 50 nm theoretical resolution.
- The pitch and yaw axis has 10 degrees of motion with a 1 arc sec theoretical resolution.
- The fiber z axis has 90 mm of stroke with 1µm resolution.
- Piezo drive system for 130 µm Z fiber motion with 100 nm resolution
- A Ring of fire translation stage with 90 mm of stroke and 6 -m resolution.
- Two orthogonal view video microscopes for fiber viewing with LED back lighting.
- Each camera captures 1600 x 1200 (2 MP) up to 16 FPS in B/W.
- Each lens is double telecentric with a 200 µm depth of field, 4.4 mm field of view, 0.03 (deg) maximum divergence, 0.02 margin of error, and 85x magnification (fiber range 400 µm - 2 mm).
- 2X Doubler adjusts fiber range to 125 µm - 1 mm (when installed)

PC to operate the system including:

- Windows operating system
- 24 inch 1920 x 1080 high resolution wide screen monitor
- USB 2.0 video capture capability
- Serial communication to splicer motherboard

* No Network connection required.

- LDS splicing software
- LDS analysis software

Ring of fire arc discharging hardware capable of splicing 2.5 mm fiber with auto balance rmware.

Accessory kit including 250 µm fiber holders, 400 µm fiber holders, user manual, quick setup guide, spare electrode set, all necessary PC and LDS interconnect cables.

Includes 1-year parts and labor warranty.

LDS System Packages and components

LDS-01-0103 - Polarization Maintaining (PM) Splicing Package

Includes the following: Theta fiber alignment; End-face inspection alignment software package; Integrated mirror for end-face alignment; 250 µm light injecting fiber holders (pr) (Custom sizes available upon request)

LDS-01-0104 - Tapering Package

Includes the following: Automated taper creation software package; Load cell feedback system; Motor speed ramping function; High precision Stages

LDS-01-0108 - Integrated Dual Piezo LDF Cleaving System Package

Includes the following: Automated cleaving of fibers; Adjustable precision cleaving location via image feedback; Cleaver software package

LDS-01-0177 - Bundling Convenience Package

Includes the following: LDS Capillary Speed Loader which facilitates rapid loading (less than 1 minute of up to 19 fibers into pre-tapered capillaries); Fixturing for 700 µm and 870 µm OD capillaries (other sizes available); Power supply; User's manual; 700 µm ber holders (pr); 1000 µm ber holders (pr); 2000 µm ber holders (pr)

LDS-01-0176 - End Cap Splicing Package

Includes the following: Vacuum based end cap holding system for supporting end caps during splicing

Optional components	
LDS Capillary Speed Loader *Facilitates rapid loading (less than 1 minute of seven (7) fibers into pre-tapered capillaries; Fixturing for 700 µm and 870 µm OD capillaries (other sizes available); Power supply; User´s manual*	LDS-01-0125
Electrodes ROF (Set)	SPT-10-1638
LDS Fiber Holders - 250 µm (pr)	LDS-01-0120
LDS Fiber Holders - 400 µm (pr)	LDS-01-0121
LDS Fiber Holders - 700 µm (pr)	LDS-01-0122
LDS Fiber Holders - 1000 µm (pr)	LDS-01-0123
LDS Fiber Holders - 2000 µm (pr)	LDS-01-0124
LDS Light Injecting PM Fiber Holders - 250 µm (pr)	LDS-01-0178
ROF Electrode Cleaning Disc	SPT-10-0761
Diamond Tip Replacement Blade	SPT-10-1570
Magnetic Brass Electrode Holders (Set of 3) for ROF	LDS-01-0094