DS1101A Fault Injection Laser System

Next-generation, optical fault injection system

KEYSIGHT

Context

The market

Optical fault injection (FI) testing has become one of the primary test methods for high-security chip products. In most setups, a variety of laser technologies is used to fulfill testing needs. We took on the challenge of combining these technologies into one modular setup — the DS1101A Fault Injection Laser System.

Our partnership

Following the successful development of the Diode Laser Station with Opto, Keysight company Riscure continued its partnership and developed a next-generation fault injection laser system with Opto, a global leader and innovator in optics design and manufacturing.

Next-generation features

The DS1101A Fault Injection Laser Station, which is the Diode Laser Station's successor, adds:

1. More flexibility for various lasers, objectives, and wavelengths.
2. More rigidity to reduce vibrations. It is also larger, fitting all target sizes.
3. Back-side imaging, zooming, and an extremely wide field of view to ease navigation over the chip surface.
4. A motorized Z-axis with closed-loop control to allow remote focusing and maintain focus over time.
5. An option to upgrade with the Twin Scan module for dual laser fault injection.

Challenges the FI Laser System Solves

1. **Testing a wide range of devices and scenarios**

   One FI laser system comprising all relevant laser sources, including a single mode diode laser, multimode diode, and diode-pumped solid state (DPSS) lasers with free beam or fiber connection

2. **Testing two locations**

   Easy to add a second spot to test two locations independently by extending the FI system with the Twin Scan module

3. **Easy navigation over a chip's surface**

   Enabled by a wide field of view, optical zoom, and back-side navigation

4. **Maintaining and keeping focus**

   Easy remote focusing capabilities with closed-loop control. Software adjusts for tilted chip

5. **Fitting and fixing any target size**

   Very large base plate with easy-to-use, flexible target fixture and coarse microscope height adjustment

Functionality

DS1101A Fault Injection Laser Station core

- Stainless steel solid frame with coarse height adjustment
- Base plate with grid and target fixture
- Microscope with exchangeable beam splitter and objective revolver for 5 objectives
- 1200 nm Diode Ring Light with 3 magnetic rings for objectives
- Visible LED illumination
- Camera (color + NIR)
- Wide field of view with optical 7x zoom
- 10x Spot Size Reducer with 3 optical power filters
- Motorized focus unit, XY stage, 3-axis control unit and joystick

Inspector FI software

- Select a reference point system to calibrate easy navigation over any rotated and tilted chip surface
- Scan chip surface to find a sensitive location by controlling XY stage and laser spot focus
- Control lasers and target communication

Optional

- Objectives (Mitutoyo NIR 5x, 20x, and 50x)
- DPSS lasers, multimode, and single mode diode lasers
- Beam splitters matching laser wavelength (370 – 532 nm) and (700 – 1,100 nm)
- Twin Scan for dual laser fault injection

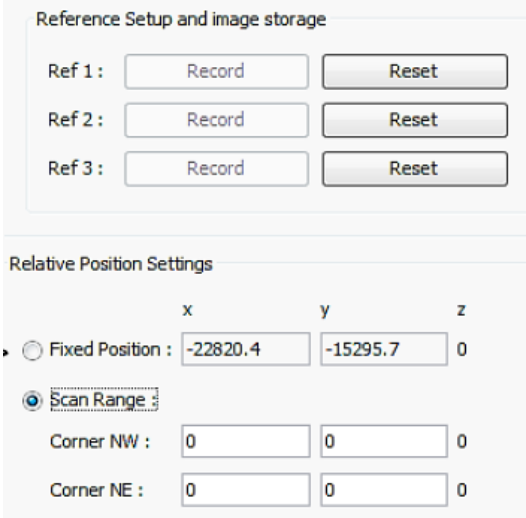


Figure 1. Compensate for a rotated and tilted chip surface with the Fixed Position setting

Unique Features

1. **All optics in one solution**

   One microscope system supporting many laser sources and various imaging techniques with various wavelengths. No need for separate systems

2. **Motorized focusing with closed-loop software control**

   Motorized focus unit for easy remote focusing, closed loop to accurately keep focus, and Inspector software to adjust focus for a tilted chip surface

3. **Optical zoom with a wide field of view and infrared (IR) illumination**

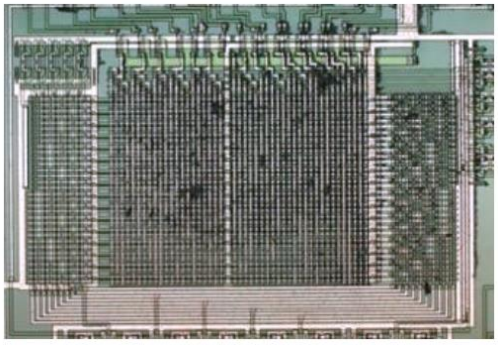
   Quickly jump between overview and detailed transistor layer images from the back side of the chip

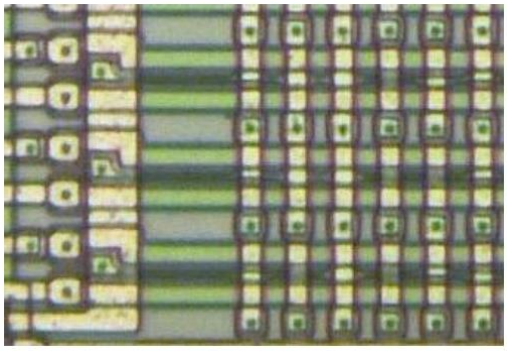
4. **Base plate with grid and a large set of target clamps**

   Fits to and fixes any size target at a reproducible location

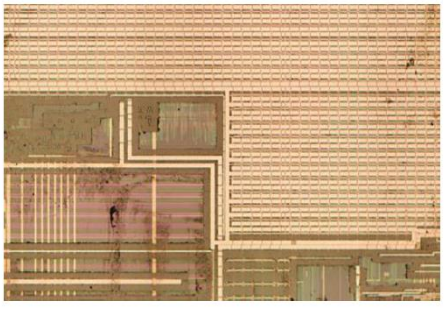
5. **Extends the FI system with Twin Scan support**

   Two laser beams through a microscope objective for optimal dual location testing





Figures 2 and 3. Jump between overview (figure 2, left) and detail (figure 3) images



Figures 4 and 5. Inspector software and a motorized focus compensate for tilted targets

Laser Sources

	Diode laser		Diode laser			Pulsed laser	
							
Color	NIR	Red	NIR	Red	Blue	NIR	Green
Mode	Single		Multi				
Wavelength (nm)	1064	980	1064	808	445	1064	532
Pulse duration	2 ns – ∞		20 ns – 100 µs			≤ 4 ns	
Time between pulses	2 ns – ∞		20 ns – ∞			1 ms – ∞	
Trigger delay			40 ns			1 µs	
Peak power	4.6 W*	5.2 W*	20 W	14 W	3 W	> 10 kW	> 7.5 kW
Spot size (µm)	Ø 1***		6 x 1.5**	6 x 1.5**	4 x 1.4**	Ø 2**	
Fiber	Only		Optional			Only	

* Measured at 50 ns, lower for shorter pulses
** Measured with spot size reducer and 50x objective
*** Measured with 100x objective

Use Case: Laser FI on SoC

The test scenario

1. Decapsulate the system-on-chip (SoC).
2. Fix the experiment board of the SoC onto the base plate.
3. Set reference points to compensate for chip rotation and tilting.
4. Find test location using IR chip image.
5. Select appropriate laser type.
6. Set text parameters as target communication, laser timing, pulse duration, power, and number of pulses.

7. Evaluate results.

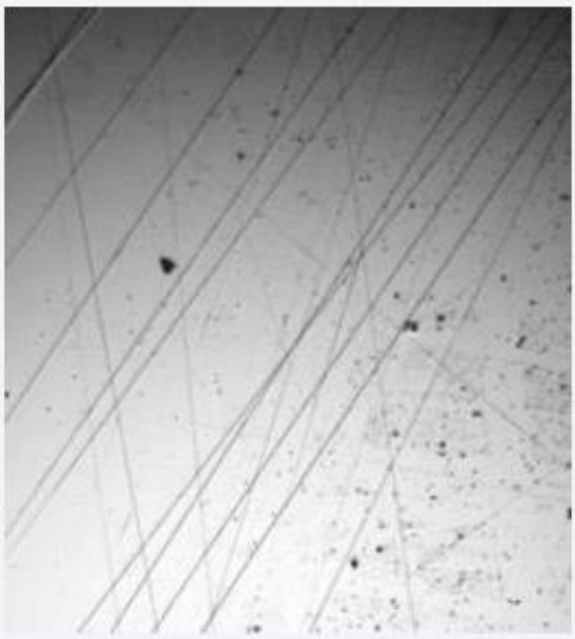


Figure 6. Test location in visible light

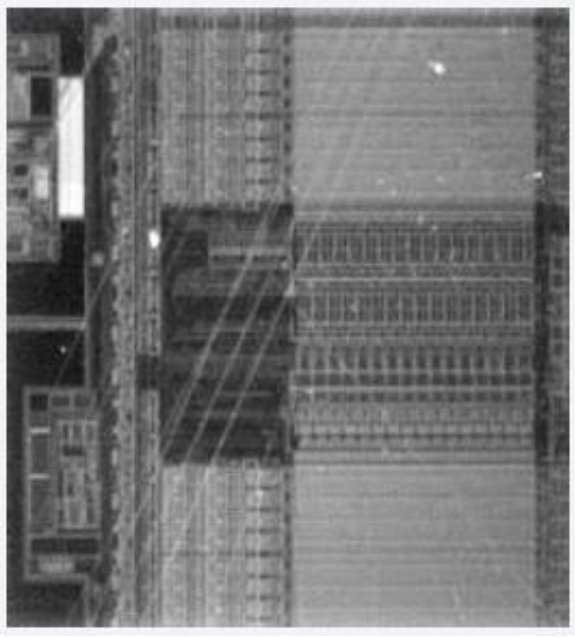
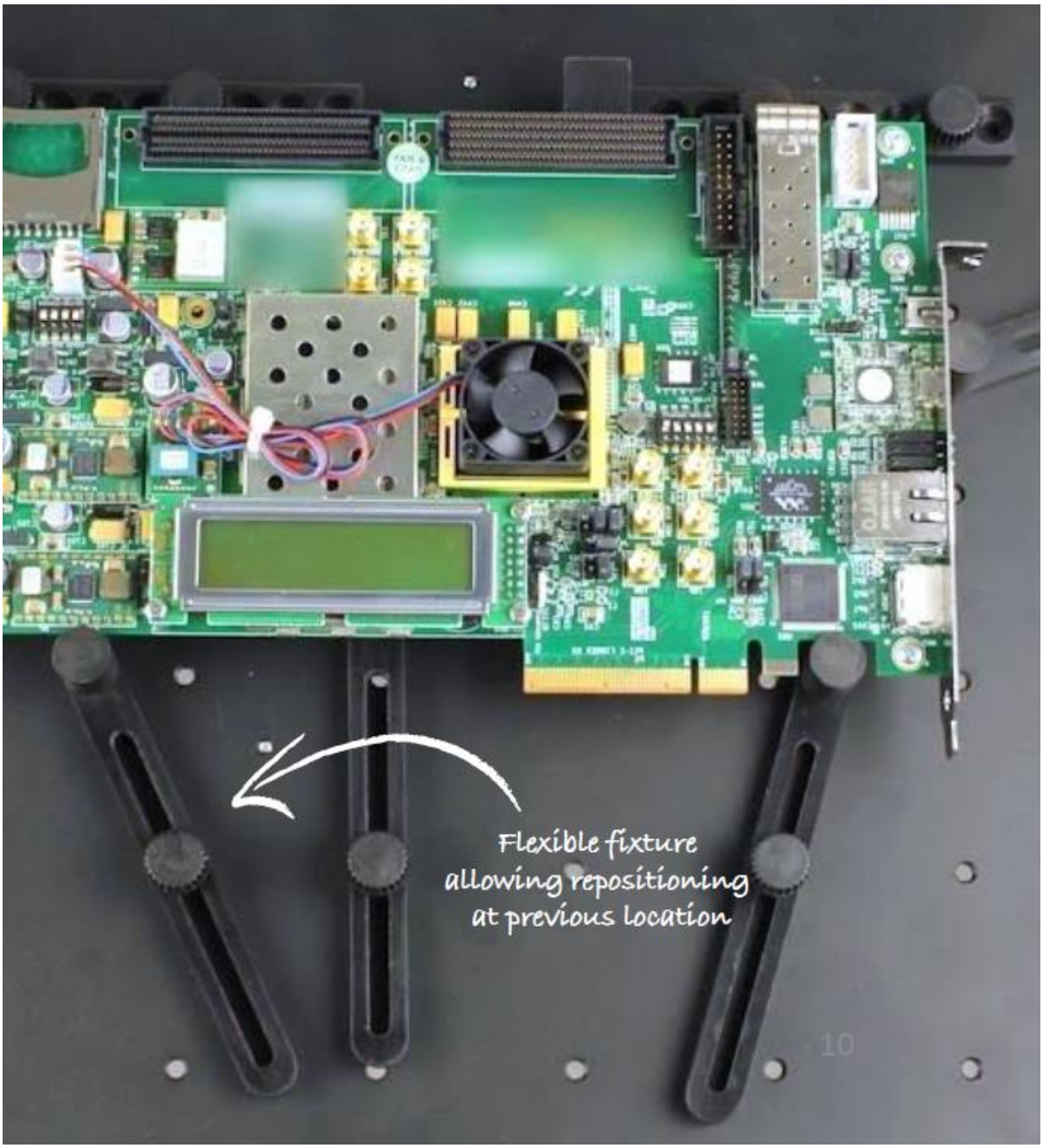


Figure 7. Test location in near-infrared (NIR)


Flexible fixture
allowing repositioning
at previous location

Technical Specifications

Camera visual light

- 1/2” Sony CMOS, color, 3.1 MP, USB 2.0

Camera NIR

- 1/1.8” Sony CMOS, monochrome, 3.1 MP, USB 2.0

Optical system

- 3 objectives (optional); magnification 5x, 20x, and 50x
- 3 filters; remaining intensity 0.1%, 1%, and 10% of laser power produced
- Spot Size Reducer for 10x reduction of spot size
- Optical 7x zoom, enables field of view changes from 3.6 mm to 0.5 mm based on 5x objective
- Laser mirrors (Beam splitters):
  - 700 nm – 1,100 nm with 80% transmission for lasers within this wavelength range. Remaining reflected light from target goes to camera
  - 370 nm – 532 nm with 80% transmission for lasers within this wavelength range. Remaining reflected light from target goes to camera

Remote connections

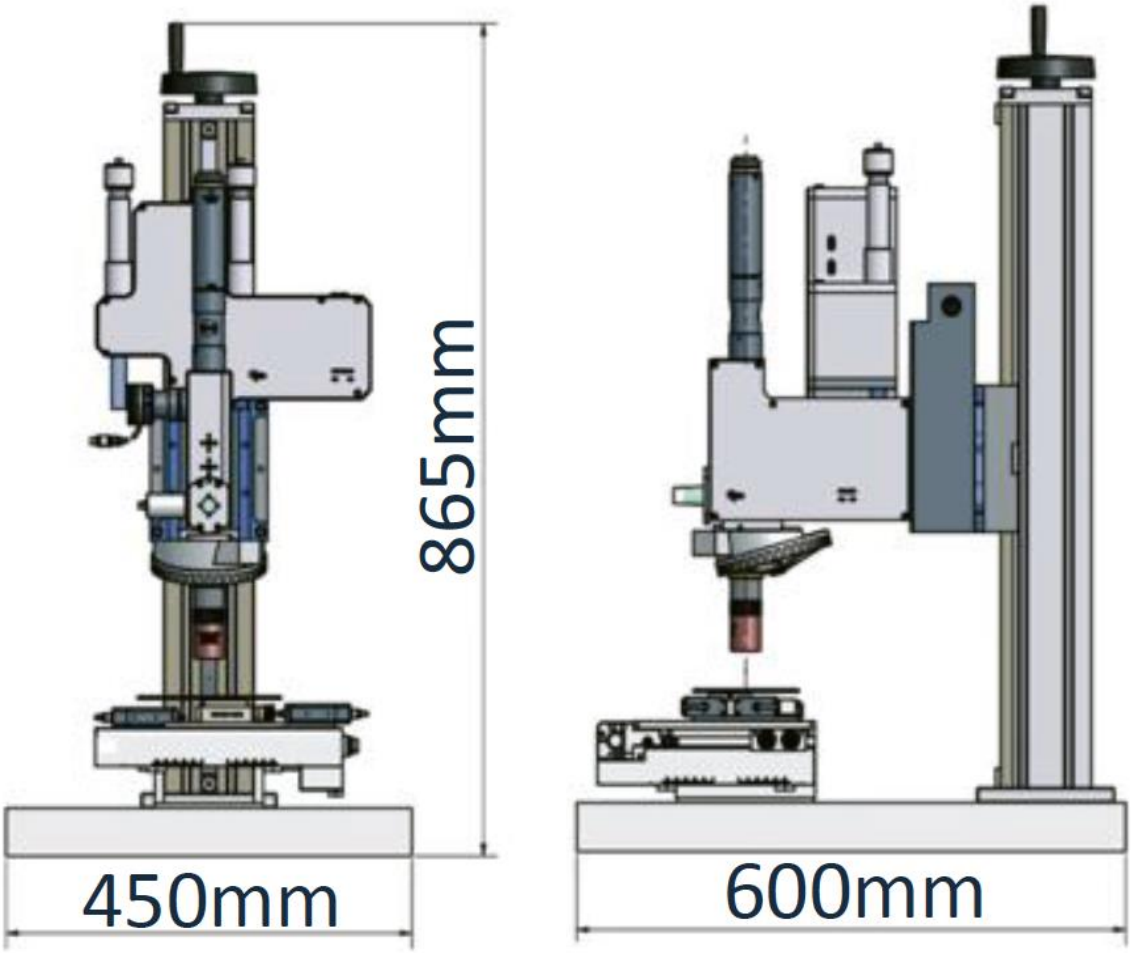
- USB 2.0 camera connection to PC
- USB 2.0 or RS232 Tango control connection to PC

XY stage

- Travel range: max. 75 x 50 mm
- Max. travel speed: 445 mm/s
- Step size: 0.05 µm
- Accuracy: ± 3 µm
- Repeatability: < 1 µm

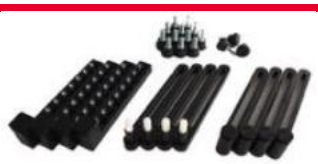
Motorized Z axis

- 100 mm travel
- 0.05 µm resolution
- Closed-loop system


865mm
450mm
600mm

Package

Quantity	Description	Photo
1	Laser station body: • Body • Zoom with color camera • Revolver for 5 objectives • LED illumination with power supply and power cable (region-specific) • Closed-loop motorized Z axis • Aperture for beam splitter (photo shows optional beam splitter installed)	
1	Laser station stand • TMC base plate • Vertical column with coarse height adjustment	
0 - 3	Microscope objectives (optional): • 5x magnification • 20x magnification • 50x magnification	
1	Tango 3 control unit (for XY stage and motorized Z axis) with: • TANGO 3 Desktop control unit • TANGO XYZ joystick • Region-specific power cable • Serial and USB cables • 3-axis driver cable • CD-ROM with driver software • Z-axis sensor cable	
1	Spot size reducer with: • 3 filters (10%, 1%, 0.1%) • Camera cable	
1	XY stage with: • Mounting screws and rings	
1	Base plate with: • Screw for fixture to XY stage	

Quantity	Description	Photo
1	Clamps for base plate	
1	IR ring light (optional) with: • 3 magnetic objective rings • Power supply • Region-specific power cable • NIR camera	
0 – 2	Beam splitters (optional): • 370 – 532 nm • 700 – 1,100 nm	
1	Safety box (optional): • The safety box can be purchased separately • For safety reasons, a safety box is required as part of the DS1101A Fault Injection Laser Station • The safety box prevents direct laser beams from exiting the box. It has an interlock system that shuts down the laser when the door is opened. The safety box has a key lock, restricting access to qualified personnel in possession of the key. The safety box has an emergency switch.	
1	Set of 4 hex wrenches: • M1.5 +M2 + M4 + M5	
1	DS1101A Fault Injection Laser Station User Manual	