DS1113A / DS1114A Diode Pumped Solid State Fault Injection Lasers

Stable high intensity lasers for green (532 nm) and NIR (1064 nm)

Introduction

Despite several limitations, laser cutter technology is still frequently used for fault injection testing because of its high intensity combined with a small spot size. The limitations are that it is challenging to control power parameters, it is heavy in maintenance, and it has unfavorable and unstable timing characteristics.

The fit-for-purpose Diode Pumped Solid State Fault Injection Lasers were created to address all the limitations laser cutters have. In addition, they complement single and multimode diode lasers due to precise positioning in combination with a very high-power level.

Figure 1. 532 nm Diode Pumped Solid State Fault Injection Laser (left), 1064 nm Diode Pumped Solid State Fault Injection Laser (right)

KEYSIGHT

Context

Partnership

Riscure, a Keysight company, partnered with InnoLas to develop suitable lasers for fault injection. For many years, InnoLas has been a designer and manufacturer of industry grade diode pumped solid state fault injection lasers.

Industry grade

Instead of using the scientific DPSS laser from InnoLas, Riscure took a laser from their highly reliable industrial range and adapted it for chip fault injection testing together with InnoLas Photonics.

Special options were selected:

- A dedicated long life light emitting diode.
- Separately gas filled sealed compartments for green and for NIR to reduce maintenance.
- Continuous pumping of optical energy to reduce time delay after trigger.

Challenges Solved

- **Efficiency loss caused by inaccurate timing of faults:** Even when you know exactly when to time your faults, you still miss the sweet spot 99% of the time due to the laser cutter's jitter. The Diode Pumped Solid State Fault Injection Lasers resolve this by offering a time-stable trigger and pulse.
- **Long delay after trigger:** The shorter the duration between trigger and fault, the easier it is to perform fault injection testing. Instead of 100 µs with laser cutters, it has been reduced to 1 µs.
- **No software control over power level:** Laser cutters are not designed for fault injection purposes and need modifications to control their (high) power level. Even with the modification it still doesn't offer the precise control that you need. The attenuator motors of the Diode Pumped Solid State Fault Injection Lasers are software controlled, allowing for ease of use and fine-grained setting of the lasers' power level.
- **Cumbersome in maintenance:** No more need for regular maintenance activities. The long-life pumping diodes provide high reliability and low maintenance compared to laser cutters. The Thermo-Electric Cooling inside the Diode Pumped Solid State Fault Injection Lasers provides accurate temperature control for laser power stability and low trigger jitter. A sealed laser container with protective gas minimizes contamination and ageing.

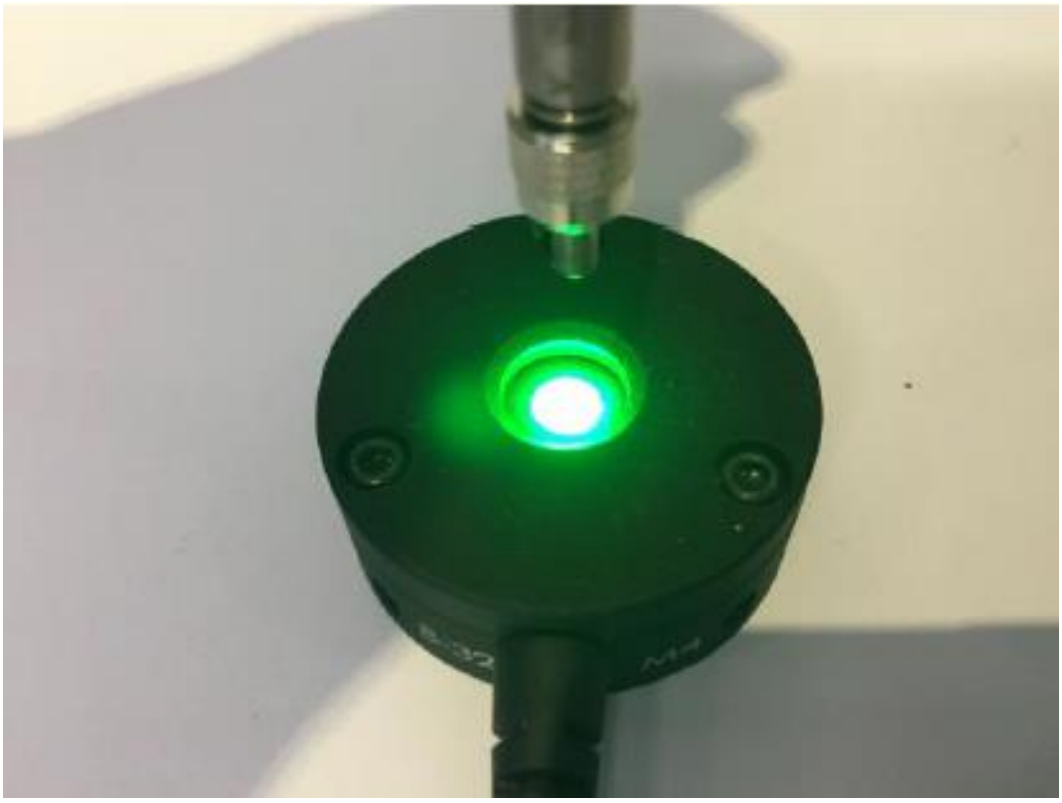

Figure 2. Lab measurements with accurate optical power sensors show high stability of pulse energy

Unique Features

1. **Control of fault timing and power level:** Boasting your efficiency in testing.
    a. Accurate timing of faults
    b. Software controlled power level to ease automation of test scenarios
2. **High power with small spot size:** Scanning the chip surface with a small spot size with high intensity faults may reveal security vulnerabilities previously undetected.
3. **No maintenance required** in the first 5 years of operation.
4. **Flexible**
    a. **Running as an independent laser source**, it can connect to any fault injection laser setup.
    b. **Plug and play** into the Keysight DS1101A Fault Injection Laser System and Inspector software for existing Keysight customers.

Use Case: Green Laser

The Diode Pumped Solid State Fault Injection Lasers come in two versions: one for green (532 nm) and another for NIR (1064 nm). Here, we describe a use case for the green laser.

We tested a hardened crypto chip's front side for robustness of the AES hardware implementation. We used the green Diode Pumped Solid State Fault Injection Lase because:

- The front side of the chip has many metal layers that green light can penetrate better than red light. Further, silicon is more easily manipulated with green light.
- We avoided hitting optical sensors in the chip due to small spot size.
- When finding a location of concern (i.e. the chip's behavior is changed by the fault) the small spot of the green Diode Pumped Solid State Fault Injection Laser pinpoints the chip engineers to an accurate location on the chip.
- We attacked round 10 of AES. A short high intensity pulse at the right point in time is delivered by the Diode Pumped Solid State Fault Injection Laser to target this round. If corrupted output is observed, we can perform differential fault analysis.

Note that with a small spot size it takes time to scan a larger area. A larger spot size can be configured for faster but less accurate testing.

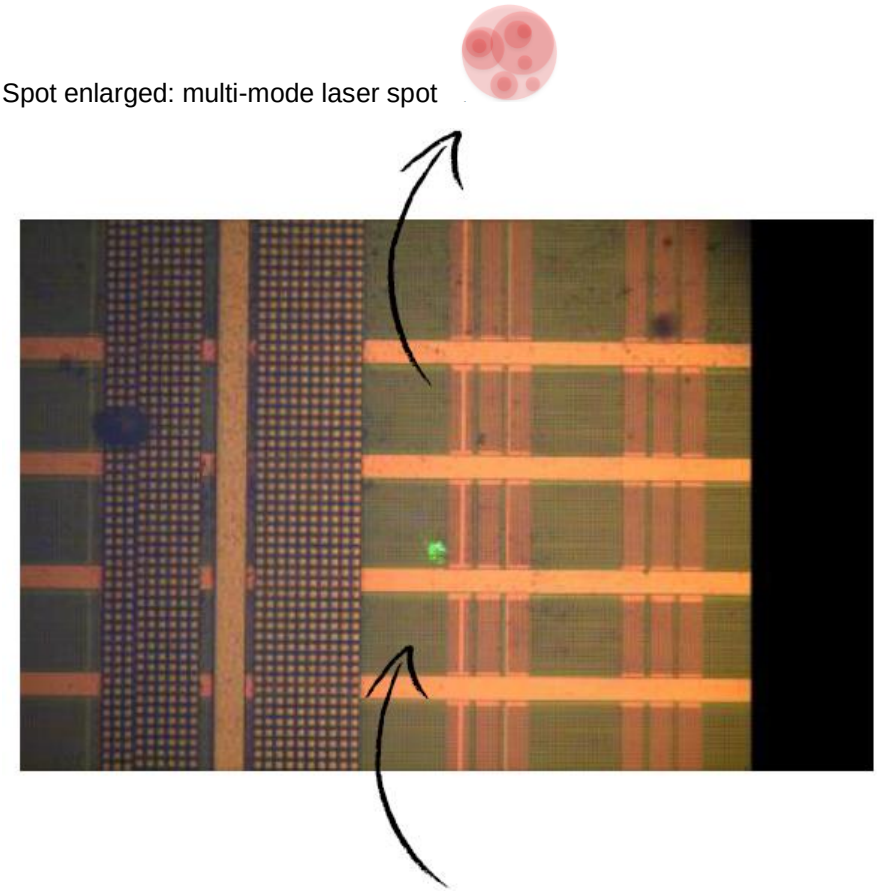

Figure 3. Green laser spot scans the metal chip surface

Plug and Play

1. Connect Diode Pumped Solid State Fault Injection Lasers glass fiber and fiber coupler to microscope.
2. Fix glass fiber to avoid too strong fiber movements which might influence optical power at target when moving due to the Keysight DS1010A Precision XYZ stage moving.
3. Fix target underneath microscope.
4. Select objective and use Spot Size Reducer to determine spot diameter.
5. Carefully increase laser power during testing to avoid damage to target.
6. Define test parameters for the fault injection test run.
7. Evaluate results.

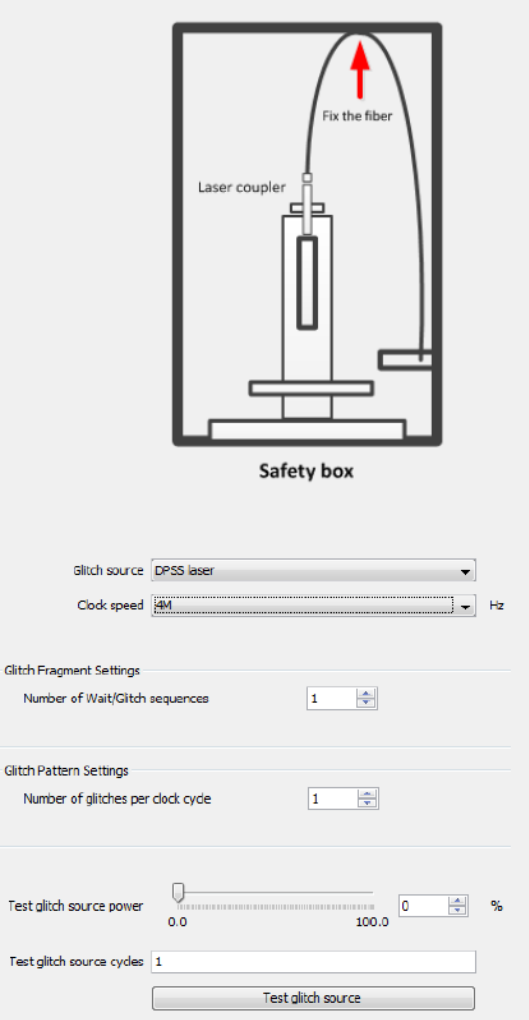

Figure 4. Plug and play

Technical Specifications

	Green	NIR
Wavelength	532 nm	1064 nm
Trigger to laser pulse delay	<1.1 µs	< 1 µs
Trigger pulse width (positive edge triggered)	>250 ns	
Minimum recharge time for next laser pulse	1 ms	
Spot size 5x / 20x / 50x objective, no Spot Size Reducer	∅ 40 µm / ∅10 µm / ∅4 µm	
Spot size 5x / 20x / 50x objective, with Spot Size Reducer (Keysight DS1101A Fault Injection Laser System)	∅4 µm / ∅1 µm / < ∅1 µm	
Laser pulse energy	≥ 30 µJ	≥ 40 µJ
Laser pulse duration	≤ 4 ns	
Power attenuator speed	from 0 – 100% < 1 second	
Laser technology	Diode pumped YVO4 laser crystal with Q-switch	
Laser class (safety)	CLASS 4 laser	

Package: Green / NIR

Quantity	Description	Photo
1	Diode Pumped Solid State Fault Injection Lasers Head, class-4, with • Cooling Cable • Laser Head Cable • Laser manual • Test Report	
1	Power supply unit (100 V to 240 V AC, 50 Hz to 60 Hz) with User Interface connector, and • Red Static Discharge Protection connector • Dummy Interlock connector • Dummy User Interface connector • USB cable • Switch on/off key set • USB memory key with installation files • Power cable	
1	Attenuator Controller with • USB mini cable • Attenuator cable (attached)	
1	Fiber Coupler (Optional)	
1	Interlock cable	
1	User Manual	