Keeping the power as low as possible for laser diode testing

By Alex McCarthy and Robin Agnew

AmFax Ltd., a laser diode testing solution company based in the UK, was developing a new product for manufacturers of tuneable laser diodes (TLDs). The PT 5200 TLD is a family of test solutions that fully automates handling, probing, thermal management, optical alignment, and functional test of Tuneable Laser Diodes at Bar, Die, and CoC levels for mass production. The tuneable laser diodes are based on Distributed Bragg-Reflector (DBR) technology requires measuring the laser power and frequency while stepping or "sweeping" through a variety of low current and temperature combinations. The production test goal is to determine the tuneable laser diode light power vs. frequency stability characteristics and then compare to pass or fail criteria. A typical stability graph is depicted below in Figure 1.

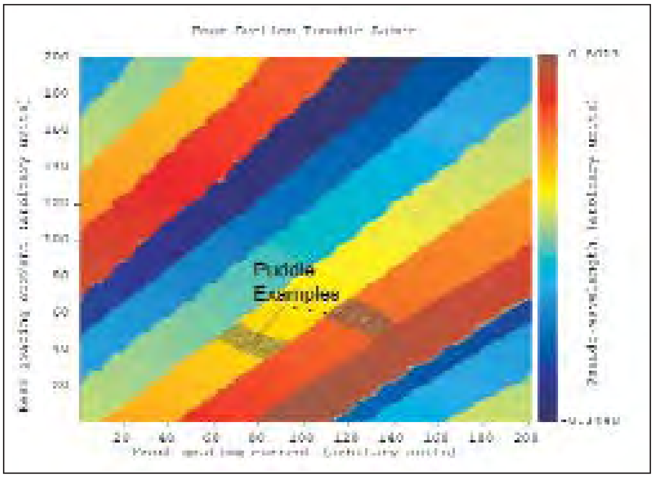

Figure 1

Low-power tuneable laser diode production test problem

Keeping the power as low as possible is a key requirement since the laser diodes in wafer, bar, or die form are susceptible to damage from large temperature gradients. Currently available test solutions take many hours, while the production requirement is a couple of minutes. Typically three current sources, an optical power meter (OPM) and a high resolution wavemeter are used. The three current sources sweep the TLD inputs through a range of currents and the power and frequency are measured using the wavemeter and optical power meter. Usually a matrix of 201 x 201 x 6 measurements are taken for each TLD. Since each measurement takes about a second, the overall time required is about 60 hours. While 60 hours may be acceptable for design validation, it is completely impractical for production test.

The test and qualification process requires synchronizing input from multiple current sources with a method for measuring wavelength. Currently, three current sources per TLD is typical, but with new TLDs with up to seven or more inputs even longer test times as a result. The input permutations are extensive, with characterization "sweeps" running into millions of steps.

Testing of the devices as early as possible in the production cycle is critical in the fight to keep costs to a minimum; the earlier a problem is found the fewer production processes have been carried out and as such less expense.

Wafer level test is not possible since the laser diodes are edge emitting; so testing at bar or individual die are the first levels of test to be considered. Bar test was not considered for this application because of the thermal effects from neighboring devices as testing progressed down the length of the bar. Testing individual die added further limits to throughput with handling, thermal control, and fiber alignment issues to be solved.

Solution description

The basic solution approach develops two automated subsystems – one for characterization and one for handling of the tuneable laser diodes. The two subsystems are then cleanly integrated.

For the characterization subsystem, with GPIB offering no route for improvement and VXI limited in bus speed, and being relatively expensive, we looked for a platform that provided the speed, modularity, synchronization, expandability, and support for the foreseeable future that we needed. PXI was adopted as the platform, which provided all of these features and more, and is also fast becoming the accepted industry standard.

PX Instrument Technology, in Ireland, develops PXI-based instrumentation specifically for the optoelectronic industry and they leveraged existing products for the additional optoelectronic instruments required.

The PXIT modular instruments address the following design criteria unique to TLD testing:

- Multiple, synchronized source measure units
- On board mass storage of stimulus and measured results

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- A method of measuring wavelength at 10,000 measurements per second with about 30 pm resolution

For the handling subsystem, AmFax used its experience of fully automated functional test solutions for single section laser diodes, SOA's and modulators at bar, chip, and chip-on-carrier level to develop specialist vacuum pick-up tools, thermally controlled test pedestals, multiple section micro-probing techniques, and fiber alignment solutions specifically for the testing of tuneable laser diodes at individual die level. As a leading developer of automated manufacturing test solutions, AmFax extended its existing standard platform to meet the new requirements.

Solution implementation and deployment

As stated above, the final solution should be considered as two individual subsystems:

A) Characterization subsystem
B) Handling subsystem

The characterization subsystem treats the handling subsystem simply as a "black box" making calls to provide a device for test as required and then, after the device has been tested, sending back pass, fail, and binning information for the handler to output the device accordingly.

Characterization subsystem

The characterization subsystem is based on PXI hardware with the addition of LabVIEW and TestStand as the programming language and test executive. Here is how the design criteria mentioned above were handled by PXIT:

A) Multiple source measure units running in synchronization:

The PX2000-305 is a single-slot PXI module that provides 0-500mA output and 0-10V input at 10,000 steps per second. The unit includes PXIT's "sequence engine" – this controls the timing of the overall sequence. In any group of instruments (there can be multiple groups of OPM, current sources, and wavemeter in every chassis) one module acts as the master and the others as slaves. The "sequence engines" on each board communicate via the PXI trigger bus. The result is that the modules look after their own operation during any given programmed sequence and will only report back to the controller (host PC) when the sequence is finished. The controller (host PC) can then upload all the stored results.

B) On board mass storage of stimulus and measured results

Both 305 and 306 modules have 2 Mbytes of static RAM for the storage of both stimulus and results.

C) A method of measuring wavelength at 10,000 measurements per second

Finally, PXIT used the optical characteristics of a WDM coupler/splitter to estimate wavelength. The optical signal from the laser is fed to the input of the coupler/splitter; the ratio of light in the two output channels of the coupler/ splitter depends on the wavelength of the light passing through. The light from the two channels is then fed to the two channels of a dual channel optical power meter (PX2000-306). A future version of the PX2000-306 will incorporate the WDM coupler/splitter.

The PX2000-306 is run through a high-speed sequence of measurements collecting the optical power readings at each step. At the end of the sequence the data is converted from the power ratios to wavelengths. This method is more suited to mass production applications where absolute accuracy is not required and is available across the C-Band. Absolute accuracy would need to be referenced to an additional source or wavelength meter, if required.

Handling system

The need for synchronized motion, vision, optical, and electrical instrumentation was critical to the success of this project. PXI offers the modularity and open standard required to enable this approach in a single chassis with a single controller. The historic need for multiple controllers increased the complexity and reduced the reliability of the system.

The handling system is based on AmFax's standard platform for the automation of optoelectronics component testing. A SCARA type robot with an out-of-the-box specification of +/- 20uM across its entire area of reach in X & Y, Z repeatability of 5uM, and theta resolution of .03 degrees provides a fast, reliable, and flexible method to pick and place operations within the cell.

The robot specification is enhanced with the integration of a number of vision systems that enable very accurate location and manipulation of the components as well as the ability to automatically calibrate the system. Placement accuracy has been improved to ± 5uM in X & Y. The vision systems are based on National Instruments iMAQ PXI hardware and software.

The end-effector (tool pod) on the robot has been specially developed to suit the tuneable laser diode testing, with a vacuum pick up tool manufactured from specialist materials and utilizing proprietary manufacturing techniques we have a 100 percent success rate in the pick and place of the die without causing any handling damage whatsoever. This technology is proprietary to AmFax and is also available for the handling of Bar and CoS level test.

The probing of the device is an extremely delicate operation and separate nano-positioning stages are employed to give the necessary control of the probe head. Beryllium copper fingers make contact with the DUT pads that are 60uM square on a 75uM pitch without causing any serious damage and provide a life of some 200,000 operations. A National Instruments PXI motion control card provides the hardware interface to the stages from within the PXI chassis.

Here we show synchronize moves and measurements reducing alignment times (see Figure 2):

A) Represents moves on X axis and respective position of necessary optical power measurements.
B) Move-stop-measure approaches take more time because measurements can only be acquired once movement is stopped.
C) Synchronized moves and measurements are faster because moves do not need to stop to take measurements with known position.

Alignment of a single mode fiber is required to provide a coupling loss of less than 3 dBm. This is achieved by the integration of the Physik Instrumente Nano-Cube that provides 100uM travel in X, Y and Z with a resolution of 20nM. With the accuracy of place-

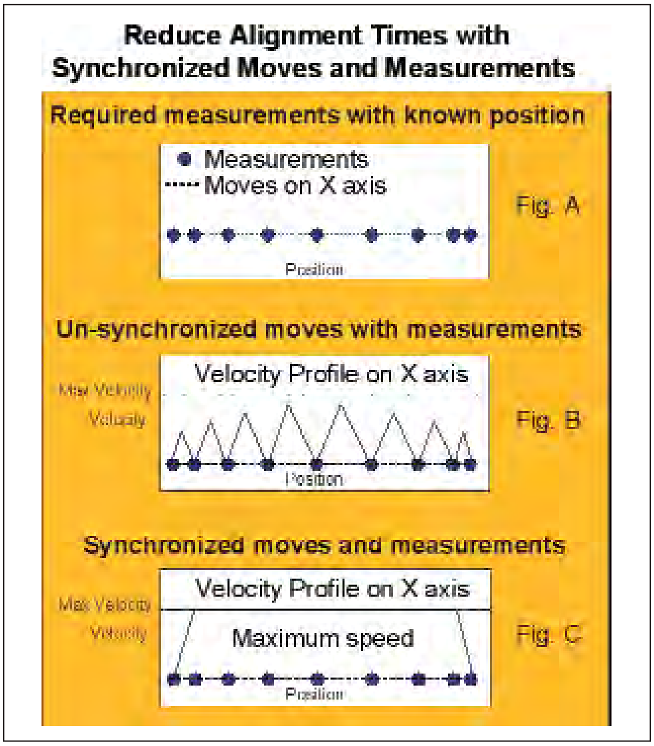

Figure 2

ment from the vision enhanced robot enables an alignment time of less than four seconds.

Results

The result is that we can run a sequence of 201 x 201 x 6 (242,406) cycles in 25 seconds with the results being collected in the onboard RAM. When the test is complete, the data is transferred to the embedded PXI controller, which takes approximately five seconds.

The solution runs at a slower rate because of effects on the tuneable laser diode – the test time including data transfer is now 90 seconds. The reduced test time greatly exceeds AmFax's requirements.

A close up view of the development system, outside of the integrated test rack, shows the scale of the instruments required to complete the solution in Figure 3.

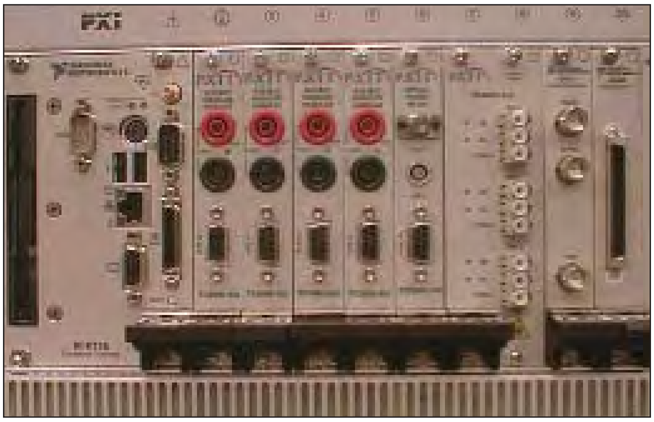

Figure 3

The small footprint allowed us to mount all of the equipment required below the robot table, as can be seen in Figure 4.

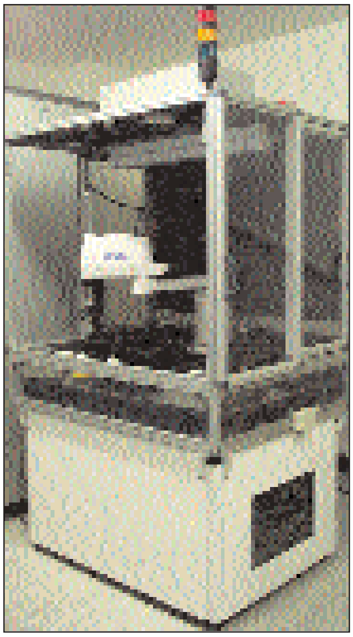

Figure 4

The layout of the system is shown in its finished form (front access doors have been removed for clarity).

The test system is housed below the robot table and hidden from view, with particular care taken to ensure that critical cable lengths are kept as short as possible by locating the instruments directly below the test head.

An operator carries out the input of DUT's. Four standard waffle trays are used to provide more than 1600 devices, when fully loaded. Operator intervention is then not required for long periods of time, up to 13.5 hours for this application.

Output trays are used to "bin" the DUT's based on the test results, with a failed DUT location that removes them from the process for further test or to be discarded.

PXI's integrated synchronization and triggering on the backplane is a large contributor to the resulting time savings since both the laser efficiency permutations and fiber alignment depend on synchronizing multiple modules. The PXI platform was selected due to the easy integration of electrical, optical, motion control, and vision hardware and software. Finally, AmFax benefits from a complete solution including: test management applications, GUI application development, wide PXI acceptance, and easily integrated measurement and control devices.

Alex McCarthy *is a member of the PXI Product Management team at National Instruments. He has been active in marketing industry-standard, computer-based solutions for more than 15 years. Alex holds a BS ChE from Texas A&M and is leveraging his past experiences to increase PXI adoption.*

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