A Photodiode-Detector Alignment System

Project Description
During the manufacturing of a tunable filter product, it requires to install a servo sub system consisting of a VCSEL (Vertical Cavity Surface Emitting Laser), a mirror, and a split detector. The mirror is sitting on a MEMS actuator already installed on the ceramic substrate for the product. The process objective is to align and attach the VCSEL and split detector to the substrate per geometric and optical requirements. The objective of this project is to design and make a process station that will guide the operator to manually align and attach the VCSEL and detector. The work includes:

1. Find an alignment scheme to achieve the geometric and optical requirements.
2. Design the system and manufacturing process based on the scheme.
3. Build/acquire all the electronic subsystems.
4. Specify the mechanical tool requirements.
5. Final system integration with application software.

What not included in the work are: mechanical tool design, bond design, and epoxy application method.

System Description
The final system being implemented is show in the left block diagram. The pre-aligned red laser-PSD pair fixes the mirror, thus substrate, position in the space by adjusting the nest. The pre-aligned IR PSD is then used to guide the VCSEL alignment. Finally, the detector is positioned by optimizing the VCSEL signal on the detector.

The substrate is mounted on a vacuum nest with 6 degree-of-freedoms. The nest has a TEC (Thermal Electric Cooler) that maintains nest temperature during the alignment and can heat up afterwards to cure epoxy. The electric contact to the substrate is done by pneumatic driven probe pins. VCSEL and Detector are mounted on to manipulating tools with and six degree-of-freedoms and electric probing capabilities.

The PSDs signals are first processed by the PSD controller boards, and then read by a data acquisition (DAQ) card. The PSD boards are developed by us and have been used for many alignment applications. The product related parts, MEMS actuator on the substrate, VCSEL, and detector, are connected to a modified board designed for the final product itself. This reduces the amount of work for the project and also makes possible station modification related with product modification easy. The product board has its own DSP processor and can be controlled through RS232 interface. Modifications are done to drive the MEMS actuator in analogy mode to speed up the alignment process. The analogy signals come from the DAQ card. Finally, a custom relay boards are build drives the laser diode and pneumatic switches using the digital IO from the same DAQ card.

For quick turnaround, all the stages are manipulated manually by the operators using the signals provided by the system. Full automation is planned once the products are mass-produced.
Software and Results
The following picture shows the graphic user interface of the applications software. On the left side is a manual controller that can manually adjust basically all the adjustable parameters of the system, from the pneumatic switch of the probe pin, product drivers, to stage temperature. The middle is the main workplace for the operation. It provides a step-by-step process guide for the operation, with two PSD position displays to indicate the beam positions. The left side is used to display the numeric results and plots. All the process data are automatically saved into database and files for data review and statistic process controls.

The system, in operation since May 2003, has been running smoothly and is the most efficient process station in the whole process flow. The step-by-step guide process results in high throughput that the process is now limited by the thermal curing time. Changes are underway to move the thermal process off the stage to free up the relatively expensive station.