Northeast Semiconductor, Inc.

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March 31, 1992

Dr. Erhard Schimitschek, Scientific Officer
ATTN: Code 808
REF: N00014-91-C-0222
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Re:	Contractor	:	Northeast Semiconductor, Inc.
	Address	:	767 Warren Road, Ithaca, NY 14850
	Req. No.	:	s405811srv02/17 APR
	Contract No.	:	N00014-91-C-0222
	Report Date	:	November 26, 1991
	Report Title	:	Fourth Monthly Technical Report
	Period Covered	:	03/01/92 through 03/31/92

Dear Dr. Schimitschek:

Northeast Semiconductor, Inc. encloses its Fourth Monthly Technical Report (Line Item #0002) pursuant to the provisions of contract Section B entitled, "Supplies or Services and Prices/Costs" for the period of March 1, 1992 through March 31, 1992.

Innovative Techniques for the Production of Low Cost 2D Laser Diode Arrays

1.0 OBJECTIVE

The primary objective of this program is to develop a low cost, high yielding methodology for processing, packaging and characterization of MBE grown two dimensional high power laser diode arrays. Projected increases in overall yield of AlGaAs diode lasers would reduce manufacturing cost from the current $10 to $20 per peak watt to below $3 per peak watt. Emphasis will be placed on innovative packaging techniques that will utilize recent advances in diamond heat sinking technology.

2.0 PROGRAM METHOD AND SCHEDULE

This program consists of four phases which will demonstrate reduced manufacturing cost and improved device performance of NSI's MBE laser diode arrays. The four phases listed below will result in milestones in processing, packaging, and testing along with delivery of the specified number of 5-bar laser arrays.

(i) <u>Concept phase</u>: Conceptual design and organization of this phase II program. NSI will utilize the current side cooled strained relief package to manufacture 5-bar laser diode arrays for base line evaluation. (Deliverables: 3 5-bar arrays.)

(ii) <u>Backplane phase</u>: Development of a copper backplane cooling technology that incorporates CVD diamond submounts. This phase will also include the completion of room temperature photoluminescence development. (Deliverables: 5 5-bar arrays.)

(iii) <u>Diamond Backplane phase</u>: Develop a CVD diamond backplane cooling scheme that will utilize smaller CVD submounts. The reduction in submount size is to decrease the thermal resistance from the laser bar to the backplane. (Deliverables: 5 5-bar arrays.)

(iv) <u>Liquid Cooled Submount phase</u>: An innovative liquid cooled package will be developed. The CVD diamond submounts will be hermetically sealed, electrically isolated and liquid cooled. (Deliverables: 5 5-bar arrays.)

The following global issues not mentioned above will be investigated continuously throughout all four phases of this program:

(1) design and development of a mask set to increase processing and packaging yields,

(2) development and updating of MBE growth software,

(3) design and development of an in-house facet coating station,

(4) evaluation of different facet coating materials,

(5) development of automated tests,

(6) life test and burn-in development.

The master schedule for this program is shown in Table 1. Each phase will require wafer growth, processing, assembly and test. The schedule shows the estimated number of sample fabrications and tests, as well as the time of hardware deliverables and reports.

3.0 PROGRESS THIS PERIOD

3.1 Wafer Growths

No laser wafers were grown for this contract in March. NSI has closed the facility at ITT's Gallium Arsenide Technology Center in Roanoke, Va. After six months of study and work on the two Varian Gen II machines purchased in 1985 by ITT and leased to NSI, we have determined that the cost to refurbish and upgrade these machines would be significantly more then the cost of purchasing new machines. Indeed, the current downtime for these two machines combined approaches 70%.

As a result of all the above, NSI has made a serious business decision to close the facilities in Roanoke, Va. and cancel its lease with ITT. Furthermore, NSI is in the process of finalizing negotiations with a fortune 100 company in the United States to provide the lease of current generation 3" production MBE machines. These negotiations should be completed in the first two weeks of April with production beginning the by the end of that month. We are fully confident that our negotiations and acquisition of their machines will put Northeast Semiconductor, Inc. far ahead in our capability to meet R&D and production delivery schedules and provide the highest quality epitaxial wafers available in the world today.

Productivity of MBE grown AlGaAs laser wafers for this program will commence by the end of April 1992. However, we presently have a sufficient stock of 808 nm laser wafers to complete the first two sets of deliverable for this contract.

3.2 Processing

ONR wafer M21362 was processed last month utilizing the new mask set developed for this program. Initial results with this mask set are encouraging. Additional work needs to be performed on optimizing the exposure dose of the polyimide to achieve a more uniform step profile in the p-side metal contact. Figure #1 shows the cross-sectional view of the contact and the metalization problem associated with over exposing (under-cutting) the polyimide. With NSI's standard 80μm stripe this problem does not exist.

Presently, facet coating failures dominate the laser yield at NSI. New procedures implemented for solving coating problems have produced more uniform layers, increasing the facet coating yields substantially. In addition to coating quality, yields are also reduced due to physical damage of the facets during loading and unloading of the jig. Investigation needs to be performed to understand and resolve problems encountered during loading operations. The current facet coating yield is at 50%.

Characterization of different front facet coating materials continued. Life test data has been taken on six arrays with TiO_2 and Ta_3O_5 as front facet materials. The results are inconclusive and do not favor one coating over the other in air or in nitrogen. The remaining laser diode bars that were involved in this experiment have massive amounts of facet damage and/or non-uniformed (shadowed) coatings. Once the facet coating yields increase to an acceptable level this experiment will be repeated.

3.3 Testing

Efforts began this month to correlate test bar data from the new ONR mask set to packaged array performance. Test bars from ONR wafer M21362 were probed p-side up with a 1µsec pulse. The data is currently being collected for both test bars and fabricated arrays, and will be included in the 2nd quartly report next month.

The life test pulser developed in this program has been utilized this past month without failure. However, longer pulse widths (over 200µsec) sufficiently depletes the charge on the capacitor bank providing unreliable power input control. Work needs to be done on increasing the charge on the capacitors by either increasing the the cap sizes and/or supplying more voltage.

Three five bar array assemblies have been tested for the first set of deliverables for this program. Figure #2 represents typical pulsed test results. At 2.0% duty cycle (200µsec pulse at 100Hz) the optical output at 60 amps was approximately 200 watts. The wavelengths are at 808nm ± 2nm with a FWHM less than 3nm operating at 60 amps and at 9°C. All three 5-bars were burned-in for 1 X 10^6 pulses at 60 amps.

3.4 Assembly and Packaging

Unfacet coated bars from wafer M21362 were packaged this past period. These arrays suffered from a failure mechanism characteristic of extreme voids in the p-side solder joint. As seen in figure #1, the solder has to contact the indented metalization between the lateral isolation grooves. Voids present in this area would facilitate the need to conduct more current through the metalization around the polyimide step. As mentioned in the processing section, the over exposure of the polyimide produced some under-cutting which results in metal thinning and breakage around the step. Probing bars at the contact, then above the polyimide produces results that support this theory. The combination of solder voids and thin metalization around the polyimide step is responsible for the device failure. A solution being investigated is to increase the amount of evaporated solder on the submount to reduce voids in the p-side contact.

Investigation into CVD diamond is being held up by the inability of the diamond vendor to deliver. Alternative suppliers are currently being contacted.

Three five bar side-cooled lasers array were fabricated in March for ONR deliverables. These arrays will serve as a baseline comparison for this program. The packaging yield for the submount utilized in these deliverables were 90.5%.

4.0 PLANS FOR APRIL

NSI will continue to utilize and characterize the new mask set for this contract. Correlation will be done on test bar results to aid in pre-packaging screening of material to increase laser yield and decrease cost. Investigation into packaging difficulties encountered with the new mask set will continue along with developments in NSI's backplane cooling technology.

Very truly yours,

Michael J. Cook,
Principal Investigator
Northeast Semiconductor, Inc.

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Encl: 1 Copy of 4th Monthly Technical Report

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DEPARTMENT : LASER PRODUCT LINE
PROJECT(S) : ONR PHASE II
N00014-91-C-0222

KEY
○ : Start Task
◇ : Milestone
△ : Completion Date 1
▽ : Completion Date 2

DATE : NOVEMBER 20, 1991
PREPARED BY : GEOFFREY T. BURNHAM
APPROVED BY :

PAGE 1 of 2

MILESTONES	1991					1992												1993							
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
HIGH YIELD EPITAXIAL GROWTH																									
SYSTEM QUALIFICATION	○				△																				
WAFER STARTS					4	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
REVIEW INCOMING INSPECTION	○					△																			
UPDATE GROWTH SOFTWARE	○																							△	
WAFER PROCESSING																									
PROCESSING STARTS					2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
DEVELOP ROOM TEMP PL TEST	○					△							▽												
DEVELOP FACET COATING	○																	△							
PACKAGING																									
1-BAR SUBMOUNTS				15	30	30	10	10	10	10	30	30	10	10	10	10	30	30	10	10	10	10	30	30	
5-BAR ARRAYS																									
CURRENT								6																	
Cu BACKPLANE													10												
CVD DIAMOND																			10						
EGW COOLED																									10
TESTING																									
DEVELOP AUTOMATED TESTS	○																							△	
LIFE TESTS/BURN-IN	○																							△	

TABLE 1. MASTER SCHEDULE FOR SBIR PHASE I
CONTRACT NO. N00014-91-C-0222

DEPARTMENT : LASER PRODUCT LINE
PROJECT(S) : ONR PHASE II
N00014-91-C-0222

KEY
○ : Start Task
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APPROVED BY :

PAGE 2 of 2 MILESTONES (CONTINUED)	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
	1991					1992												1993							
TESTING (CONTINUED)																									
5-BAR ARRAYS								○																	△
DELIVERABLES																									
REPORTS																									
MONTHLY				△	△		△	△		△	△		△	△		△	△		△	△		△	△		
QUARTERLY						△			△			△			△			△			△			△	
FINAL																									△
5-BAR ARRAYS																									
CURRENT								3																	
Cu BACKPLANE													5												
CVD DIAMOND																			5						
EGW COOLED																									6

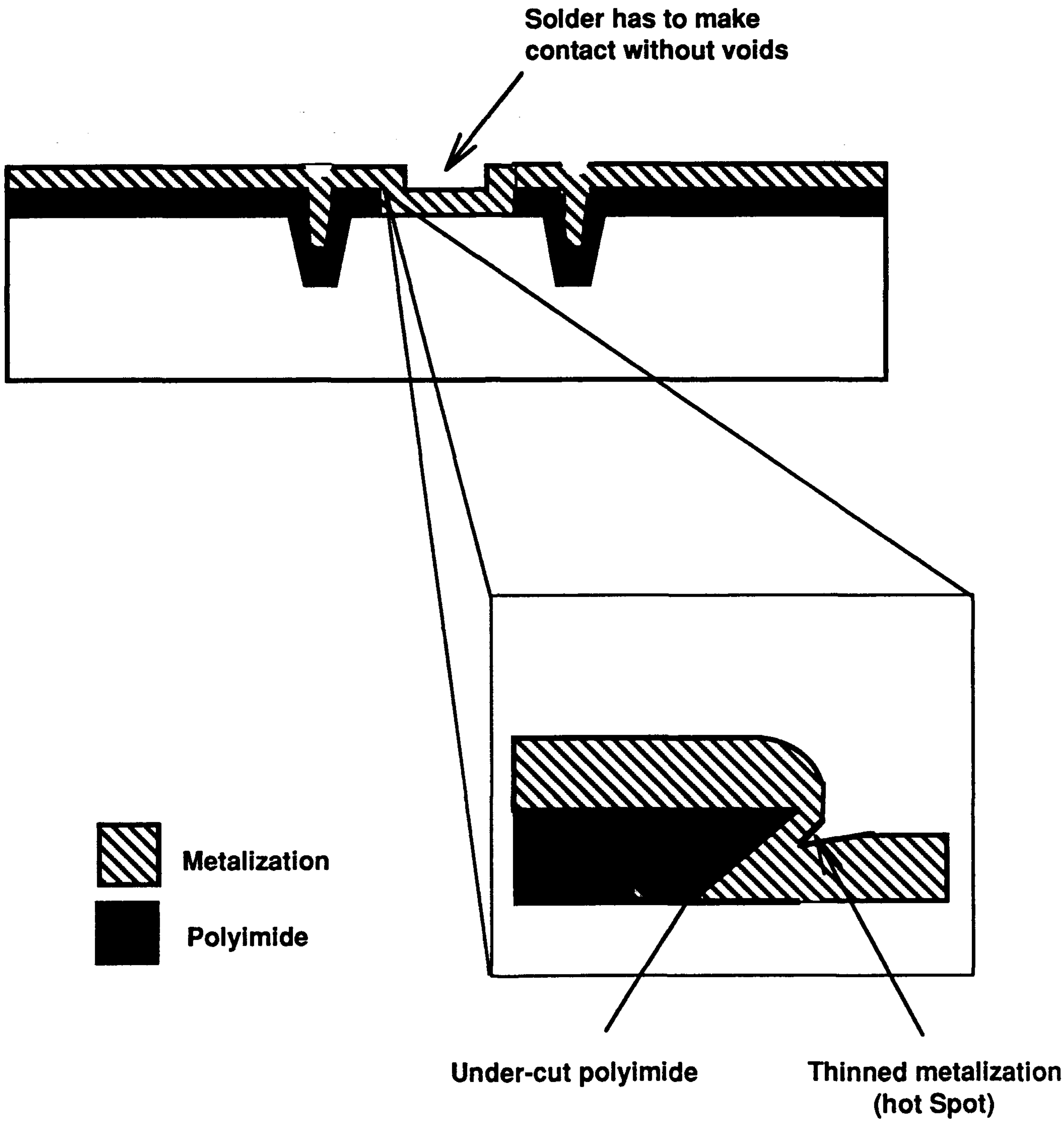
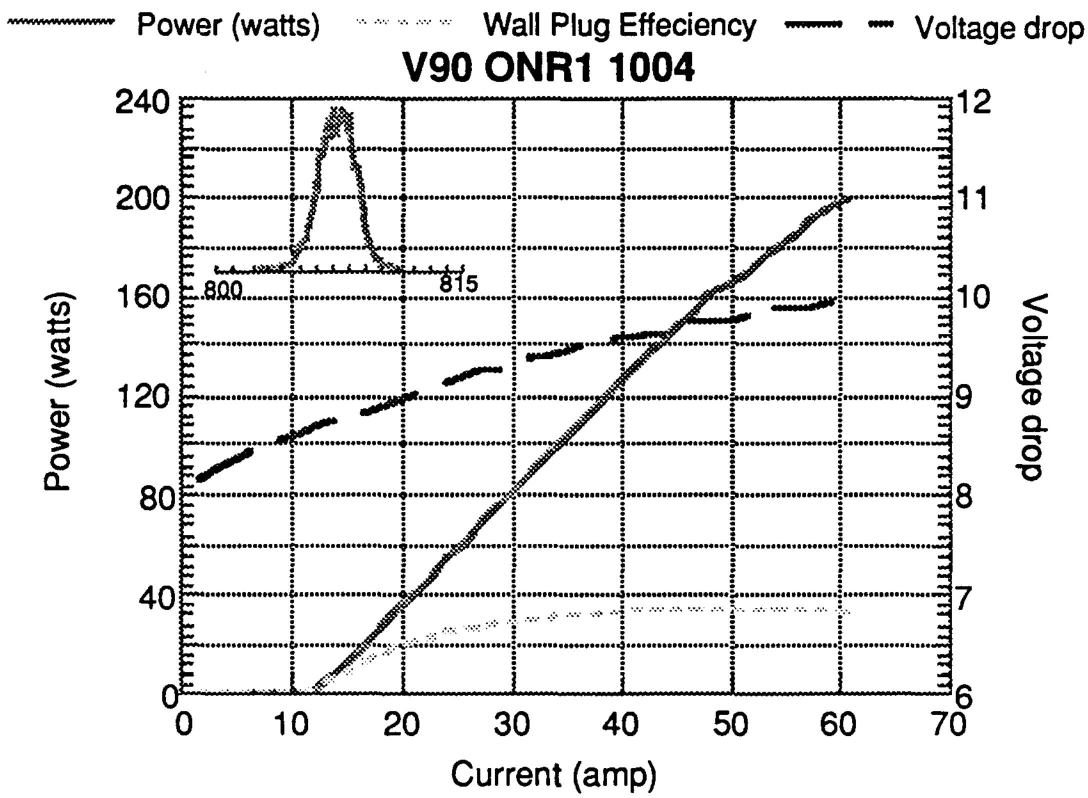


FIGURE 1 CROSS-SECTIONAL VIEW OF LASER DIODE PROCESS
CONTRACT NO. N00014-91-C-0222



operating conditions:

duty cycle: 2.0% (200µsec pulse at 100Hz)
temperature: 8° - 10°C
current at spec. wavelength: 60 amps

FIGURE 2 TYPICAL PIV DATA ON FIRST SET OF 5-BAR DELIVERABLES
CONTRACT NO. N00014-91-C-0222