

# University of Arkansas Microelectronics-Photonics Graduate Program

## PhD Candidacy Exam – March 2005

### Photonics Area of Emphasis Exam

#### PROBLEM TO BE SOLVED

You are the chief engineer of a company that currently produces Erbium-doped fiber. These fiber products are presently sold to large OEMs that make complete systems and sell them to telecommunications customers that want to restore the quality of optical signals without converting to electrical signals. Your management team is very interested in expanding into devices that optically pump the fiber. Since a separate division of your company currently makes quantum well edge-emitting laser diodes, there is strong interest in the potential to adapt this technology base to make semiconductor optical amplifiers (SOAs). However, no one has yet made the comparisons to see if the SOA is the best solution for optically pumping a fiber amplifier.

Your job is to study the requirements for coupling optical energy into an Er-doped fiber for amplification purposes and to make recommendations on an overall system approach. You should develop a proposed design for an optical pump module that can be directly attached to an Er-doped fiber, along with the method of attachment. You should provide a comprehensive survey of competitive technologies, along with analysis of strengths and weaknesses of each approach, and make recommendations for your company's product development. Specifically on this recommended approach you need to evaluate the required equipment, infrastructure and the resulting cost of implementing this technology. You should clearly (but briefly) explain SOAs, how they work, and your rationale on why your company should or should not attempt to adapt current technology to manufacture SOAs.

The objective is for the optically pumping system to meet the following requirements. Clearly explain any issues that will prevent these goals from being met:

- High coupling efficiency with less than 3 dB of loss from optical pump to fiber
- Nominal pump wavelength of 980 nm, stable to 85 C
- Single mode module output, FWHM of 10 nm or less (input to fiber)
- Minimum number of couplers, lens and filters
- Sales price of less than \$5,000.00 in volumes of ten thousand units per year
- Capable at 10 Gbps, with plans to increase to 40 Gbps
- Simple, reliable attachment to fiber, using active alignment to within no better than 0.5 microns tolerance

## **YOUR DELIVERABLE**

Your task is to write an internal proposal for your corporate officers describing your approach to this issue. Be sure you address all of the following:

**Current Technology** - What is already being done in this area by other researchers, companies and governmental institutions? The current state-of-the-art for both the science and the implementation should be described, making use of diverse resources such as science literature, journals, conference proceedings, the internet, patents or other sources of existing public knowledge. Be sure to cite all references used.

**Your Proposed Implementations** - Describe in detail how where you plan to use these devices and how they will benefit these applications. Include both the scientific/engineering basis and method of applying this to a workable solution.

**Manufacturing Flow** - Detail the step-by-step procedure for making these structures in a form useful in manufacturing.

**Testing and Qualification** - Describe a set of tests and demonstrations that you will use to demonstrate the effectiveness of your approach.

**Cost Analysis** - Perform a cost analysis that includes, at least, acquisition of raw materials, labor rates, costs per operation, etc. assuming quantities of 10,000 parts per year. You may exclude from your analysis possible additional costs in such infrastructure areas as human resources, facilities engineering, janitorial and grounds, upper level management, etc. You must include all direct manufacturing costs, both startup and continuing; and you must discuss explicitly space and personnel requirements to set up a stand-alone product line. Generic per process costs for various manufacturing methods can be used, as long as they are rationally applied.

**Intellectual Property** - List all IP sources that were consulted while formulating the answer, and include the full list of examined documents as an appendix to this exam. (The full list will not be counted as part of the 15-page limit.) From this list, identify the three that are the most significant threats to the IP you have created in your solution.