University of Arkansas Microelectronics-Photonics Graduate Program
PhD Candidacy Exam – March 15, 2002
Photonics Area of Emphasis Exam

As a senior photonics development engineer for one of the world's largest optical telecommunications manufacturers, you have been given the task of developing a "unique" device for increasing the data transmission rate over fiber optic cables.

The new and revolutionary product is a wavelength multiplexing and demultiplexing device.

Specifications for the design include the following:

- The ambient temperature will not exceed 85 C.
- 1024 wavelength channels centered at 1.5 microns
- Less than 2 dB/cm loss through the device
- Cross-talk to be less than –10 dB
- Power consumption to be less than 1 watt
- Physical size target is less than 1 cm^3

Part A (must be answered):

In order to prepare a preliminary design, it is necessary to choose a multiplexing/demultiplexing concept. What materials do you recommend? Why? What optical alignment methods will be used? Sketch the cross section of the design indicating the expected signal transmission, the optical components used and the optical losses expected at each interface. You must estimate the required dimensions, both vertically and laterally. State any and all assumptions that are made.

You are now responsible for developing a preliminary optical design. Address the role of optical spot size, wavelength dependence of the device concept, choice of materials, magnitude of any applied voltage, discrimination between wavelengths and efficiency, as well as the necessary fabrication techniques that must be used in order to implement your design.

Part B (address two of the four following items):

1. Design a system to evaluate the performance of each device and demonstrate that it meets the specified requirements.
2. Develop a process flow that can be used to fabricate the complete optical design, including means for coupling the light in and out of the device. You must include, in sufficient detail, information such as equipment type, temperatures, processing materials used, etc.
3. Construct a thermal model to predict the behavior of your device under temperature variations. Your calculations should be based on first principles. Propose a viable thermal management technique to maintain the integrity of components in your design. Show, via calculation, that your technique is successful.

4. Perform a cost analysis from front end to back end-that is, from acquisition of raw materials, labor rates, costs per operation, etc. assuming quantities of 1000 parts per year. Create a list of all parts required for fabrication of the device. 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 this stand-alone product line.

Part C (must be answered):

Consider the intellectual property content of your solution described in Part A. Determine if there are any existing IP public disclosures that would restrict implementation of your solution, describing in detail the potential conflicts of the three closest IP publications. List all IP sources you consulted while formulating your 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 your 15 page limit).

Part D (must be answered):

The system you designed in Part A has been shipping from your factory for 24 months, and you are receiving some units back from customers due to degradation in the transmission and wavelength selection, resulting in intermittent performance. It is your task to perform failure analysis on the returned systems.

1. Describe the information you will seek from your customer base to help you determine the reason for the transmission and wavelength selection problems.
2. Propose the three most likely hypotheses explaining why the systems failed in this fashion. Describe the analytical techniques, tools, and instruments that you will use to investigate the cause of the transmission problems, etc., including the reasons that these techniques/instruments are the most appropriate to help you clearly determine which of your three is the correct hypothesis.

Part E (must be answered): Your management team is concerned that the degradation problem will continue in the field, and they wish to abandon the current design approach. Evaluate the possibility of alternate techniques that could be used to replace or enhance your existing design. Consider both current and projected technologies.

Your answer to Part E should be in the form of an upper level management white paper. It should contain sufficient detail to convince your management team of the merits of your analysis, and should be written with the objective of securing the necessary resources to support a detailed technical examination of the most favorable alternate communication scheme identified in your report.