

## **University of Arkansas Microelectronics-Photonics Graduate Program**

### **PhD Candidacy Exam – Environmental Topic – March 16, 2012**

#### **PROBLEM TO BE SOLVED**

Sustainability provides a way to fulfill social, economic, and other requirements of both current and future generations by balancing human and natural conditions. Reassessing work practices to develop sustainable alternatives such as green chemistries, manufacturing operations, information technologies, and engineered products may provide new jobs, reduce emissions, and improve economics relative to existing processes and products.

Your company specializes in finding innovative and transformative new approaches to long-standing problems by harnessing emerging micro to nanoscale technology. Your CEO is interested in harnessing recent advances in materials, processes, devices, and/or systems to develop one innovative, cost-effective, specific technology in a single area of your choice related to green manufacturing, green engineered products, or green information technologies. For example, conventional semiconductor fabrication requires high-purity starting materials, specialized environments such as clean rooms and high vacuum, and repeated post-processing steps to achieve acceptable production specifications. Each of these requirements consumes energy derived from fossil fuels. A novel, environmentally conscious process to produce important semiconductor materials that minimizes energy consumption and prevents waste/pollution by using benign reagents at atmospheric conditions could be considered.

Examples of technologies to consider might include alternative base materials with higher tolerance to impurities or improved fabrication techniques or processes. Environmentally friendly computer displays based on new materials, alternatives to printed wiring boards, alternative circuit connectivity methods of components to these boards, or printed circuit boards incorporating flame retardants might offer compelling economic, ecologic, or social advantages. Improved design enabled by micro/nanoscale technology could result in hardware or software alternatives with substantially improved computing power at a fraction of current energy usage levels with accompanying smaller carbon or thermal footprints.

Your task is to apply your background in nano to micro materials, devices and processing to develop *one* cost-competitive, practical, innovative green technology to apply to *one* of the above (or closely related) areas. Your solution should consider material, process, device, and system aspects of the technology and product.

#### **YOUR DELIVERABLE**

Your task is to write an internal proposal for your corporate officers describing your approach to this issue. The proposal should include the following:

- Executive summary (one page)
- Risk assessment roadmap form (one page)
- Full proposal (15 pages maximum)

- Appendix A: Bibliography (no page limit)
- Appendix B: Ranked list of intellectual property documents examined (no page limit)

**At a minimum, be sure you address all of the following:**

**Current Science and Technologies** - What is already being done in this area by other researchers, companies and governmental institutions? Describe the current state-of-the-art for both the science and the implementation. Use diverse resources such as science literature, journals, conference proceedings, the internet, patents or other sources of existing public knowledge. *Cite all references you use and quote any word-for-word transfer to your report.*

**Your Design Approach** – What is the basis for your design approach to the problem? Why is your product better than existing products? What product attribute(s) allow market penetration to achieve profitability? Address scientific *and* engineering aspects of these questions.

**Testing and Qualification** - Describe a set of tests you will use to demonstrate that your approach is effective and that your implementation of the solution will launch successfully.

**Cost Analysis** – Identify cost and market issues that will impact the pricing strategy of the solution you have proposed. Consider such things as: the major cost items that would impact the implementation; which elements of your implementation solution would be handled in-house versus externally-sourced; major risk elements that could drive up costs if the primary path item fails; costs of IP licensing needed, etc. Provide justification and/or reasoning behind your decisions. Estimate manufacturing cost for the total system as the product reaches mature product stage, so the marketing team can determine potential market size. Avoid subcontracting manufacture or assembly of any proprietary component outside the company, because the CEO is concerned with potential IP leakage.

**Intellectual Property** – In Appendix B, list in rank order of importance *all* commercial, academic, and governmental IP sources that were consulted while formulating the answer, including reference data. For instance, include the patent number; title; inventor name; and assignee name for a patent. Discuss the 3 most significant IP documents affecting your approach to your solution in the 15-page document. Compare strengths and weaknesses of these approaches relative to your own. Recommend how these IP threats should be handled.

**Most importantly** - this is just a minimum list of issues you might consider. There may be many more. The point is that your report *should contain the evidence* needed to make an effective and compelling case to your CEO in order to insure that she makes the right decision.

**Hint** – Clearly state your hypothesized solution. Identify its innovation(s) and advantages relative to state of the art. Describe both existing data, and work needed to support each aspect of the hypothetical solution. Consider theoretical, fabrication, and characterization aspects: for each, identify software/equipment and methods to use, parameters to vary, anticipated outcomes, and possible alternatives in the event of unsatisfactory results. Discuss material, process, device, and systems aspects of your solution. *Refine* your hypothesized solution as you accumulate information and prepare the manuscript. **Remember:** clearly distinguish what is known from what is hypothesized or not known. What is needed to distinguish the important things to know?