

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

### **PhD Candidacy Exam – Biological Topic – March 16, 2011**

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

One of the fourteen Grand Challenges identified by the National Academy of Engineering is to “reverse-engineer the brain”. Reaching new milestones in healthcare, computation, and communication that are encompassed in this Grand Challenge requires advances in micro- and nano- technologies (e.g. materials, processes, devices, and/or systems) to measure, characterize and understand individual nerve cells, complex neural networks, and overall brain activity.

Your CEO is interested in harnessing recent advances in materials, processes, devices, and/or systems to develop one bio-inspired, cost-effective, specifically-focused technology in a single area of your choice related to reverse engineering of the brain.

Examples of opportunities in the area of healthcare could include a technology that allows diagnosis, treatment, and/or prevention of systems-level neurological disorders like Parkinson’s, Alzheimer’s, or dementia; a technology that ameliorates neural damage related to memory loss, blindness, or prosthetic limbs at the level of the organ or tissue; or a technology that supports measurement or modulation of membrane proteins, ion channels, neurotransmitters, or other biomacromolecules or dynamic circuits at the cellular or subcellular level.

Examples of opportunities in the areas of computation or communication could include a technology that supports developments in artificial intelligence, neural network computing, or forecasting complex disasters or events at a systems level; a technology that advances speech recognition processes or machine vision devices that allow even immobilized patients to communicate with others; or a technology that supports progress in electronic logic gates that assume multiple levels of excitation or computer switches that form more than two or three connections.

Your task is to apply your background in nano to micro materials, devices and processing to develop a technology that addresses this Grand Challenge. You are expected to develop *one* cost-competitive, practical, innovative technology in *one* of the above (or closely related) areas. Your solution should consider material, process, device, and system aspects of the technology, in order to address a critical need in healthcare, computation, or communication in the realm of reverse engineering the brain.

#### **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 competitive approaches 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 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?