

University of Arkansas Microelectronics-Photonics Graduate Program

PhD Candidacy Exam – March 14, 2003

Materials and Processing Area of Emphasis Exam

I) BACKGROUND:

Chronic alcoholism results in the death of some 19,000 Americans every year due to liver disease alone and a further 13,000 from alcohol-related traffic accidents. The NIH estimates the total cost of alcohol disease, accidents, lost time, and treatment to be \$160 billion, more than all illegal drugs combined. Many of these victims desperately want to escape this addiction, but are unable to do so by either practicing abstinence or by using alcohol-reactive noxious drugs such as AntiBuse.

Your job, as chief engineer of the new company, is to design an implantable device or devices that will measure the level of blood alcohol and administer a countermeasure to prevent it from increasing above a level of 0.05% and to come up with the right product approach that will allow you and your partners to sell the company off in five years, leaving you to take up the knitting that you have always wished you had time to do (this just means that you should show that the company could be financially successful within 5 years). But before you start counting stitches, there are a few technical and business problems to be solved.

You must address all pertinent aspects of the materials and processing of this device. This should include materials of construction, how they are assembled, their reaction to their environment, suitability for implantation, how in-vivo (“in-vivo” means inside a living organism) chemical sampling will be accomplished, prevention of leakage, etc. Fortunately, there are two aspects of this problem that you do not have to consider, since you have teammates to develop solutions. First, an electrical engineer will translate the control logic you specify into a schematic and, also, you do not need to be concerned with FDA acceptance testing and criteria. But it will be up to you to both identify and address the technical issues that are vital to the unit’s success as a marketable product.

II) SCIENCE BASIS AND PROPOSED SOLUTION: (Science emphasis)

A. Establish the Science Basis

In this first part, examine and report on the current science of the use of implantable devices for measurement and control of alcohol in the bloodstream, and its’ limitations. Begin with a general discussion of the system but also describe in detail the theoretical aspects of the system and each of its components. The current state-of-the-art 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. Demonstrate an up-front understanding of the science limits behind the technology, making rigorous theoretical arguments leading to a proposed solution. (If you do not find current science

on this specific application, then base your report on the science behind implantable devices in general, along with the science behind various control mechanisms.)

B. Compare and Contrast

Compare and contrast the implantable devices with any other methods that you can find or imagine for preventing excessive consumption of alcohol in the targeted population. Distinguish the implantable devices from external device approaches or other approaches in terms of fabrication process, yield, size, convenience, etc. One of the products should then be selected on the basis of criteria you define, defended logically, and a research/development plan should be proposed to fully develop the product. (Again, if there are limited examples of external devices to control alcohol usage, then compare to other such external devices or methods that you might envision.)

List the advantages and disadvantages of each and propose solutions for improving the existing technology. Provide details on the figure of merits used to compare the systems.

C. System

Elaborate on the selected implantable device solution, defend it logically, and propose a research plan to test the solution. Include a detailed description of the system that you will implement. Include at least one diagram of the system being proposed. Cite references that provide similar systems to the one proposed. Although a literature review is required and expected, some originality is expected when designing the system.

III) DEMONSTRATION OF A NEW PLATFORM: (Entrepreneurial engineering emphasis)

In this section, you should demonstrate your understanding of how the technical issues interplay with the business, marketing, manufacturing and economic issues involved in launching a new product.

You should 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 100,000 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.

In short, tell us everything that needs to happen to make your company, and the product you have chosen to develop, a roaring success. Make sure the logic you employ comes through in your writing, which should be carefully proofread. You will have to make lots of assumptions given the vague nature of the problem definition; this is OK as long as you state what those assumptions are and why you made them. Real life is a lot like that.

A. Prototype

Provide a detailed quantitative proposed model resulting in performance specifications of the system. This should include a complete diagram indicating materials of construction, seals, electronics, etc. Discuss the steps necessary to package the system for commercialization. Define specific reliability testing that will be completed prior to market introduction, along with the justification for each test.

B. 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.)

C. Marketing analysis

Discuss the business, marketing, manufacturing and economic issues involved in launching a serious investigation of the proposed solution. Sources of available components and the cost should be listed. Identify potential customers of this system and how the technology will be applied. Estimate the number of customers and the number of systems that will be sold.

D. Broader impacts, future directions or new markets where concepts can be easily applied

In one or two paragraphs, discuss the impact and benefit to society and how to broaden the impact and to disseminate information as the research proves to be successful. Finally, you should make recommendations on future directions for investigation.