**TM: Thermal Management for High Power Electronic Devices**

**PROBLEM STATEMENT**

LED lighting technology is becoming more pervasive and finding applications in high power uses such as street lights, industrial lighting, billboards, etc. High-power LEDs can offer 5-10 times the lumens per watt compared to incandescent lights. However, as LEDs becomes higher powered, they generate more heat. Unless this heat is removed, it can be detrimental to the color quality, efficiency, and life span of LED products. Currently, ceramics such as aluminum nitride (AlN) are used, but the material is expensive and hard to work with according to R&D 100 nominee, Cambridge Nanotherm Ltd, [www.camnano.com](http://www.camnano.com). They have come up with a new nano ceramic aluminum substrate to remove the heat. Since this is a competitive market, more innovation can bring the cost down and also opens new markets. Opening these markets can be of value to the company as more thermal management opportunities come to the forefront which can be impacted by developments in nanomaterials.

You are the Chief Technology Officer of the company that specializes in nanomaterials and thermal management of electronic devices. Your CEO believes that the company’s expertise in micro to nanoscale materials, processing, and devices could provide a research and development path to meet the challenge. The objectives of this research are: (1) to identify the current technology development in thermal management for LED devices or other high power electronics devices; (2) to develop new and innovative nanomaterials and processing to meet the challenge of removing heat from these devices in a cost efficient manner; and, (3) to clearly demonstrate how your new base technology would both avoid IP infringement issues with technologies in item (1) and provide a clear advantage to potential customers.

Your job as CTO is to deliver a complete proposal with your plan for the company to compete in this area to your CEO by your Tuesday morning, January 19th deadline.

### **YOUR DELIVERABLE**

Your task is to write an internalproposal for your corporate officers describing your idea for research and development. The proposal should include the following:

* Executive summary (one page)
* Risk assessment roadmap form (one page)
* Full proposal (15 pages maximum)
* Appendix A: List of references (no page limit)
* Appendix B: Ranked list of intellectual property documents examined (no page limit)

**Most Importantly** – The significance and novelty of your creative solution, one that moves the boundaries of knowledge outward, will be the primary assessment focus of your review panel. The list below is just a minimum list of issues you might consider. There may be many more. The point is that your proposal ***should contain the evidence*** needed to make an effective and compelling case to your CEO in order to insure that she/he makes the right decision.

**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 use quotes for 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 technology better than existing technologies? What technology attribute(s) make it likely to penetrate the market and be purchased by LED and high power electronics manufacturers for use in their commercial products? 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 technology reaches mature 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.

**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?

*Reference the 2016 PhD Candidacy Exam Guidelines document for general instructions.*