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small innovations
for big solutions™

micro fuel cell labs

January 25, 2005
Mr. Lucky One
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Project Proposal for a Micro Fuel Cell Testbench

Dear Mr. One:

Please find attached the document, *Proposal for a Micro Fuel Cell Testbench*, outlining our project for ENSC 440. The purpose of the project is to design and implement a micro fuel cell testbench capable of performing rigorous testing on the National Research Council's design of a novel micro fuel cell. The testbench will perform real-time data acquisition of the micro fuel cell operating parameters while also being capable of operating as a stand-alone system which can be used to demonstrate the micro fuel cell for consumers and potential investors.

The attached document introduces our proposed design for the micro fuel cell testbench. The proposal also provides information regarding the micro fuel cell industry, the importance of having a reliable testbench, the MFC Labs company organization, our proposed schedule for completing the project, and our budget and funding.

MFC Labs was founded by Arash Jamshidi, Sarang Toosi, Olha Lui, and Shirin Farrahi. Our team members have experience in a wide range of technical disciplines including hardware design, firmware design, mechanical design, and LabVIEW programming. In addition, we are fortunate to have members who are experienced in small business start-ups, intellectual property, and business law. Please feel free to contact me at (778) 288-4911 or by e-mail at sfarrahi@sfu.ca for more information regarding our project.

Sincerely,

Shirin Farrahi

Shirin Farrahi
Chief Executive Officer (CEO)
Micro Fuel Cell Labs (MFC Labs)

Enclosure: *Proposal for a Micro Fuel Cell Testbench*

micro fuel cell labs

Proposal for a Micro Fuel Cell Testbench

Project Team
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Submitted to
Lucky One – ENSC 440
Mike Sjoerdsma – ENSC 305
School of Engineering Science
Simon Fraser University

Date: January 25, 2005

Executive Summary

MFC Labs is an ambitious start-up company dedicated to the goal of commercializing micro fuel cells for portable power applications. Our first product, the MFC Testbench, will be a cheap and portable device for testing micro fuel cells. The MFC Testbench will speed up the time to commercialization of micro fuel cells by allowing for accurate and exhaustive characterization of a micro fuel cell's operating parameters while also being a useful tool for demonstrating the working fuel cell to potential investors. Our product will be completed by the end of April 2005 and will immediately be put into use for testing the micro fuel cell developed by the National Research Council of Canada's (NRC) Institute for Fuel Cell Innovation (IFCI).

At MFC Labs we are excited to be working on a project that will move micro fuel cells forward into the market for supplying power to portable electronics. The micro fuel cell market encompasses a wide variety of applications from entertainment and information technology to medical devices and cordless tools. Micro fuel cells offer several advantages over conventional batteries including instant recharging and longer lifetimes. There are currently no large producers of affordable and portable test equipment for micro fuel cells, providing an excellent opportunity for MFC Labs to enter the market for micro fuel cell test equipment.

MFC Labs is made up of four ambitious electronics engineering students with experience in a wide range of complementary areas. Our technical experience encompasses all necessary areas of the MFC Testbench project including hardware and mechanical design and software and firmware development. In addition, we have marketing and small business development skills, as well as expertise in Canadian and US intellectual property protection. We are all good team players and communicators and have a history of success in numerous engineering projects.

In our proposal for the MFC Testbench project, we outline our preliminary design and describe how it will provide a modular solution that is easy to expand for future models. Our testbench will also be easy to use, reliable, and affordable. Our schedule of activities describes how we plan on completing the project by the end of April 2005 with specific time allocations for ordering parts, module completion, integration, and design modification. Our budget indicates that the MFC Testbench prototype development will cost roughly $970. NRC will be providing the necessary seed money of up to $1000.

The growing fuel cell industry secures a considerable market share for our MFC Testbench product. Entering the market at its early development stages, we are confident that our stand-alone and reliable testbench will be a highly demanded tool for the development of micro fuel cell technology. We are in the right place at the right time.

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1. Introduction

Fuel cells are the energy source of the future. They offer the potential for clean, quiet energy generation for applications ranging from heating your home to powering your laptop. Of all the fuel cell applications under development today, the area of micro fuel cells has the greatest potential for immediate commercialization in the portable power market [1]. Micro fuel cells offer high efficiency, instant recharging, and longer lifetime compared to conventional batteries. By using methanol as a fuel, micro fuel cells can be used safely and recharged instantly in a variety of portable electronics from laptops, PDAs, and cell phones to video recorders, portable tools, and hearing aids. Micro fuel cell technology will offer portable electronics consumers freedom from their reliance on power cables for recharging their devices. Consumers will be able to rely on a longer lifetime from their micro fuel cells, reducing the presence of dead batteries in our landfills [2]. In a market worth over $5 billion US per year, micro fuel cells have the potential to revolutionize the way we power our portable electronics [3].

Canada is currently one of the world leaders in fuel cell development technology, and we are fortunate to live in Vancouver, the country's fuel cell capital. One of the major players in Vancouver's fuel cell cluster is the National Research Council of Canada's Institute for Fuel Cell Innovation (IFCI). At IFCI, a successful group of researchers led by Kevin Stanley has developed a novel micro fuel cell. This fuel cell can provide power density of up to 10 mW/cm^2 and has many benefits over existing micro fuel cells including its flexible design and small thickness [4].

Two patent applications have been filed for IFCI's micro fuel cell, and there are already companies waiting to use the innovative fuel cell in their portable equipment. The next step in commercializing the IFCI micro fuel cell is performing rigorous testing to accurately quantify how it will behave in portable electronics. Currently all testing of the micro fuel cell has been done manually using a digital multimeter, a very time consuming and inefficient task. Commercial test equipment for fuel cells is only available for large automotive and consumer applications, and therefore is not suitable for testing the micro fuel cell. MFC Labs has been founded to fulfill IFCI's great need for a cheap, reliable testbench for their micro fuel cell. Our MFC Testbench will speed up the development of IFCI's micro fuel cell by providing autonomous, rigorous testing of the fuel cell's behaviour. The testbench can be left to run on its own while IFCI researchers work to optimize their micro fuel cell's behaviour and determine potential applications for its use. Furthermore, the testbench can be taken to tradeshows and used for demonstrations. Therefore, the MFC testbench will not only provide rigorous testing for improving the micro fuel cell, it will also promote the micro fuel cell to potential investors.

This proposal outlines the MFC Testbench design. We also propose a preliminary schedule of MFC Labs' activities and a budget for the testbench project.

2. System Overview

The main function of the MFC Testbench is to provide a stand-alone, portable, durable, accurate and easy-to-use measurement system that can help researchers demonstrate their micro fuel cell in tradeshows. In addition, the system can be used to characterize the voltage, current, and other operating parameters of a micro fuel cell under test for many hours. Figure 1 shows a graphical representation of the MFC Testbench operation.

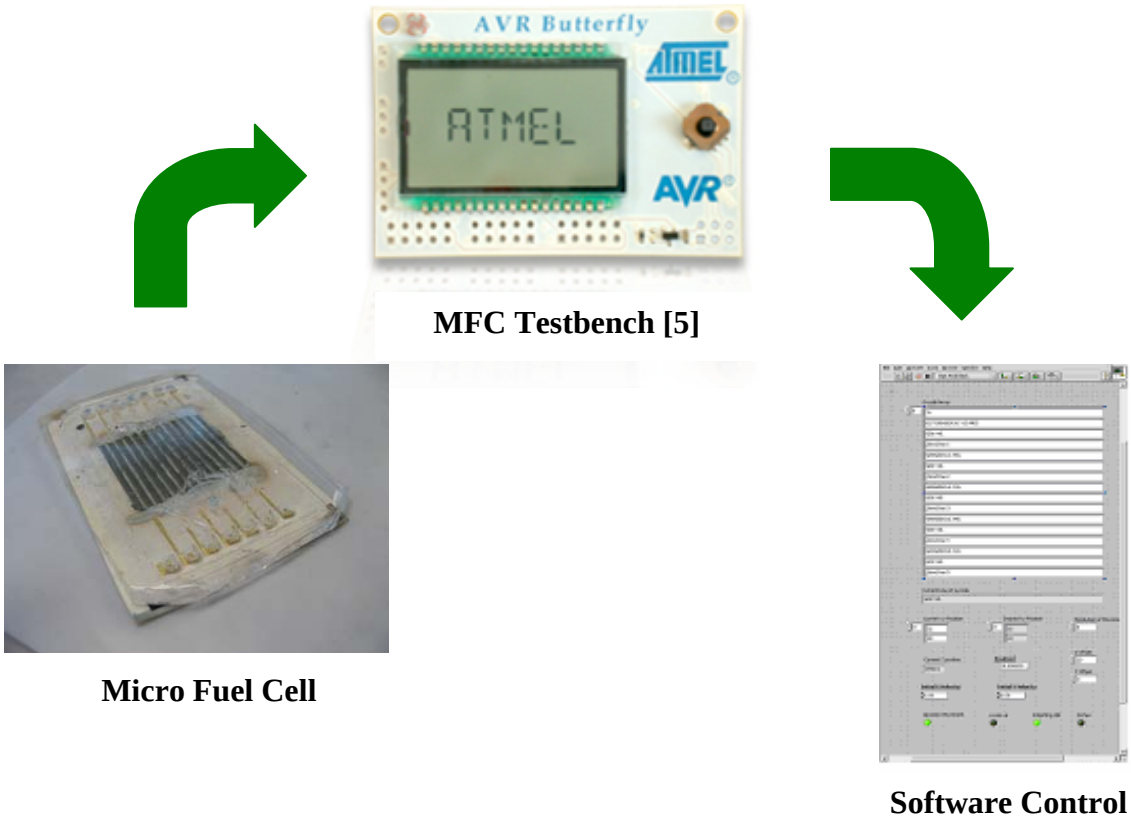

Figure 1: Graphical Representation of MFC Testbench System

The micro fuel cell developed by Kevin Stanley's group at the Institute for Fuel Cell Innovation is shown in the lower left of Figure 1. This fuel cell will be connected to our testbench and can be controlled by a graphical user interface shown in the lower right. The micro fuel cell operating data will also be shown on the testbench Liquid Crystal Display (LCD) as seen in Figure 1.

3. Proposed Design Solution

Figure 2 shows the block diagram of our proposed design solution. The sections that follow give a more detailed explanation of each block's function.

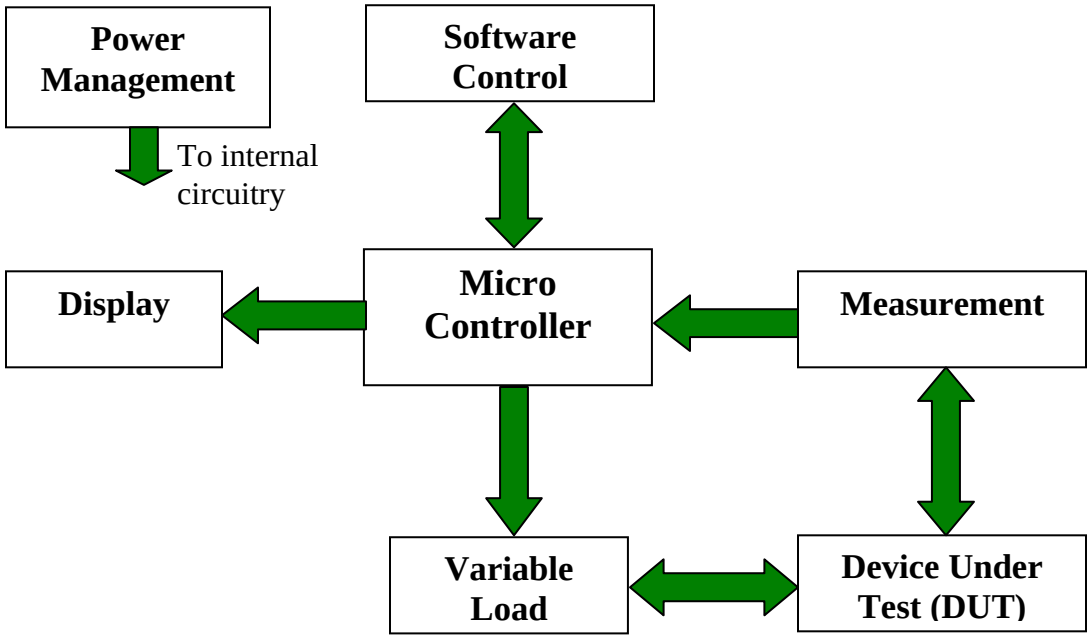

Figure 2: Block Diagram of MFC Testbench Proposed Design Solution

Measurement Block

The Measurement block communicates directly with the fuel cell and the variable load to measure the fuel cell's operating current, voltage, temperature, humidity and methanol fuel flow rate. To measure the current and voltage, we propose to use an auto-ranging multimeter that is suitable for the desired range of current and voltage. To measure temperature and humidity, separate sensors will be used that can be placed to achieve maximum accuracy of measurement. To monitor the flow of the methanol supply, a flow meter will be used that is connected to the external tank. The measurement section communicates directly with the microcontroller to transfer the acquired data.

Variable Load

The variable load block provides two methods for changing the load of the fuel cell under test. The first method is a digital potentiometer that can be controlled by the computer software through the microcontroller. The second method is a manually adjustable potentiometer that enables researchers to change the load value in absence of a computer.

Device Under Test (DUT)

The device under test section consists of the micro fuel cell and the methanol supply. The micro fuel cell is connected to the measurement and variable load blocks to complete the desired test circuit.

Display

The display is an LCD that is controlled by the microcontroller to display the running micro fuel cell parameters such as voltage, current, and temperature.

Microcontroller

The microcontroller communicates with all major blocks of the testbench. It communicates with the measurement block for data acquisition, the display to show the operating values, the variable load to change the computer controlled load, and the computer to send the acquired data and receive specific instructions.

Power Management Unit (PMU)

The power management unit consists of different voltage regulators to power the onboard circuitry. The board can also be powered from an AC adaptor which adds greatly to the possible length of operation of the device.

Software Control

The board can be connected to a computer for transferring of acquired data and also receiving specific instructions for changing the load value.

The main constraint in the development of the MFC Testbench is the tight timeline. The project has to be completed in thirteen weeks which is very ambitious for completing all of the different blocks. In addition, the controlled supply of methanol to the micro fuel cell and flow of the products of the reaction are complicated processes that are not fully understood [6]. Building the methanol supply section of the MFC Testbench will be a challenging task. However, we are confident that we will be able to complete most of the major measurement and control sections of the project.

Dividing the MFC Testbench into functional blocks as described above creates a modular design that allows for the addition of new features to the board. Some potential features for the upgraded version of the MFC Testbench include having onboard control of the rate of flow of methanol and having the option of testing multiple micro fuel cell units. The onboard microcontroller, display, and manually controlled variable load make the board a stand alone testing device that works in absence of a computer.

After analyzing the specifications of the MFC Testbench project, we determined that our design is the most appropriate, and no other designs are as suitable for this application. We were not able to find any existing testbenches on the market for small fuel cells to compare with our design.

4. Sources of Information

Our major source of information on micro fuel cell basics and the requirements for the MFC Testbench is Kevin Stanley's research group at NRC. We will also be using the Internet and the library for books and articles that might be necessary for market research, learning about fluid flow, etc.

Our major sources of information on technical issues related to the MFC Testbench design are datasheets and user manuals. We also have access to a wide range of expertise on various technical issues from our fellow engineering students and the professors of engineering at Simon Fraser University.

5. Budget and Funding

Table 1 illustrates the estimated cost breakdown for the MFC Testbench. Each bolded line in the table represents a subsystem of the product. These cost estimates may change as the project progresses; however, the primary design has been done in such a way to keep the cost fluctuation within 5% of the subtotal budget. In case of severe design changes or late ordering, the included contingency fund covers the cost of the components and express shipping charges.

Table 1: MFC Testbench Project Cost Summary

Expenses	Supplier	Cost (CND$)
LCD Display/Driver	National Semi.	**50.00**
Microcontroller/Measurement		**110.00**
Development Kit	National Semi.	110.00
Power Management Unit		**65.00**
AC/DC conversion	Digikey	20.00
Battery management	RadioShack	45.00
Variable Load		**30.00**
Active Load	Digikey	20.00
Passive Load	Digikey	10.00
Sensors		**390.00**
Temperature	Digikey	20.00
Current	LEM	40.00
Humidity	Digikey	30.00
Flow meter	GPI	300.00
Packaging and Assembly		**30.00**
Tubes /Tank	Home Depot	30.00
Marketing		**40.00**
Web site (per 6 months)	1 & 1	40.00
Misc. (passive elements, cables, etc.)	Digikey	**40.00**
Shipping		**50.00**
SUB TOTAL		**805.00**
Contingency Fund @ 20%		**161.00**
TOTAL		**966.00**

The project is fully supported by the National Research Council of Canada (NRC) for the start up amount of up to $1000. However, since the apparatus for controlling methanol supply is expensive, we may request for more funding through NRC depending on our need.

6. Time Schedule

Figure 3 presents the Gantt chart for the MFC Testbench project. The team members assigned to each task are identified by the initial of their first name.

ID	Name	Resource Initials
1	Research	
2	Methanol fuel cell (FC)	All
3	Market research	Sh,O
4	LabVIEW research	Sh
5	Fluid flow for meth.	O
6	Microcontroller development system	A,S
7	Concept	
8	Concept design	All
9	Concept selection	All,A
10	Detail design	
11	Functional specs	All,A
12	Hardware design specs	All,S
13	Software design specs	Sh
14	Module design	
15	Ordering parts	S,Sh
16	Test plans	All
17	Testing parts/mock FC	A,S,O
18	Late ordering	Sh,S
19	LabVIEW program	Sh
20	Measurement block	O,S,A
21	Variable load	A,O
22	Power management	S,O
23	Prototype integration/testing	
24	Integration of blocks	All
25	Mechanical assembly	O,S
26	Methanol supply/FC connection	O
27	Debugging/Prototype modification	All
28	Documentation/website	All/O

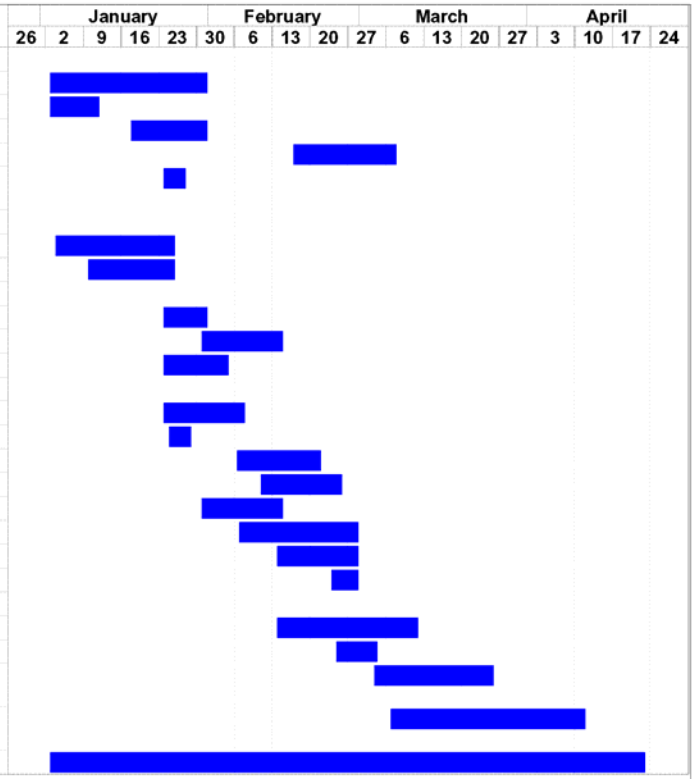

Figure 3: Gantt chart for the MFC Testbench project

Figure 4 presents the milestones for the MFC Testbench project. Other than the deadlines for ENSC 305/440, we have added milestones on February 21 and February 28, 2005 where we expect to have our main functional blocks working individually. We expect to have them integrated and working with a mock micro fuel cell by March 14, 2005. By March 25, the integrated MFC Testbench should be working with a methanol fuel cell.

ID	Task Name
1	Project proposal
2	Oral presentations
3	Software/Variable Load Block
4	Functional specs
5	Measurement/Power Management Block
6	Design specs
7	Preliminary demo
8	Methanol supply
9	Group presentation
10	Postmortem

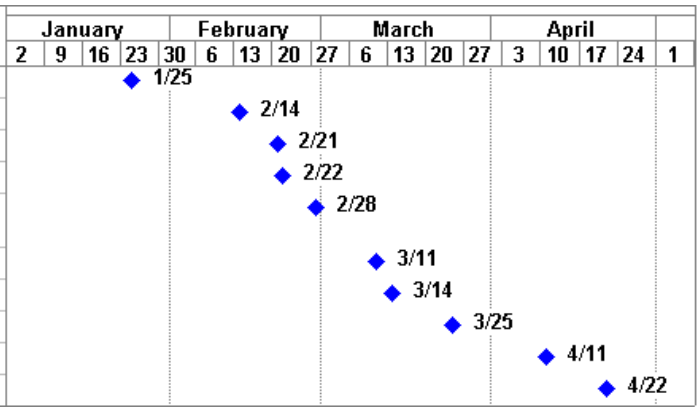

Figure 4: Milestones for the MFC Testbench project

7. Description of Team

MFC Labs is made up of four ambitious electronics engineering students with experience in a wide range of complementary areas. Our technical experience encompasses all necessary areas of the MFC Testbench project. In addition, our group's record of success on our co-ops, previous group projects, and small business start-ups prove that we are capable of achieving our goals for the MFC Testbench project.

Shirin Farrahi is the Chief Executive Officer (CEO) of MFC Labs. She will be in charge of making executive decisions and ensuring that all activities are completed according to the proposed schedule. She will also be heading the company's software development and documentation divisions. MFC Labs' Chief Technical Officer (CTO) is Arash Jamshidi who will oversee all aspects of the testbench design to ensure that integration will go as smoothly as possible. Arash will also be in charge of the hardware design and development division of the company. Olha Lui is the Vice President of Marketing (VP Marketing) for MFC Labs. In this role, she will supervise all marketing material including our website, logo, and letterhead. In addition, Olha will be in charge of the mechanical design division of MFC Labs. Sarang Toosi is our Chief Financial Officer (CFO). He will be supervising our budget and expenses and is also responsible for the firmware development division of the company.

To ensure that our group works efficiently on completing the testbench prototype, we have distributed the tasks so that we are all working in parallel on different parts of the project as shown in our Gannt chart (Figure 3). To keep everyone informed of the different components of the project, we will be sending regular e-mail updates of our progress and will be posting any important results or documents on our website at www.mfclabs.com. Our project binder and lab journal are another means of communication between group members and will ensure that we maintain organized and accurate records of the project. We are extremely proud of our strong team and have included a summary of our diverse qualifications below.

Shirin Farrahi – CEO

Shirin Farrahi is a fourth-year Electronics Engineering student. Shirin completed a four-month co-op placement with the National Research Council's Institute for Fuel Cell Innovation (IFCI) where she became intimately familiar with the structure of their micro fuel cell. At IFCI, Shirin used LabVIEW programming to create an automated setup to print in three dimensions. Her knowledge of the micro fuel cell's operation and her experience with LabVIEW programming will be valuable assets to MFC Labs. In addition, Shirin is a natural leader as shown by her past experience leading large projects. She was editor of her high school yearbook and CEO of SecuriTech, a company founded as part of a business of engineering course by ten SFU students including Shirin and Olha Lui. SecuriTech's founders were awarded second place in the Ken Spencer Business / Engineering Venture Plan Competition for their business plan.

Arash Jamshidi – CTO

Arash Jamshidi is a fifth year Electronics Engineering Student at Simon Fraser University with three co-op experiences at New Media Innovation Center (NewMIC), Sierra Wireless Inc., and SFU Medical Image Analysis Lab (MIAL). Arash has had extensive experience in hardware design and assembly of electronic circuits. At Sierra Wireless Inc., he was working as a hardware designer on the design and development of a debug board for testing and debugging of their Voq product line which they proudly called “the next generation of smart phones”.

Olha Lui - VP Marketing

As a Law school graduate and a fourth year Electronics Engineering student, Olha brings a unique blend of skills to MFC Labs. Olha’s previous research with Dr. Bonnie Gray at Simon Fraser University has given her a solid understanding of fluid flow and experience in design of fluidic microsystems. She has experience in mechanical model design and simulation using ANSYS. Her technical skills also include programming in Java and assembly, designing graphical user interfaces for real time systems, and designing analog circuits. Through her co-op work with TMS Technologies, Olha gained insight into the operation of a start-up company, planning strategies and personnel organization. On the creative side, Olha has experience with design of websites and corporate and promotional materials using CorelDraw, Dreamweaver and Photoshop. Her expertise in Intellectual property, contract and license negotiation, as well as conducting market surveys and fundraising bring a unique marketing strength to MFC Labs. In addition, Olha is a good team player and an excellent communicator.

Sarang Toosi – CFO

Sarang Toosi, CFO and Firmware lead at MFC Labs, has worked as a system engineer at Cellex Power Inc. where he was in charge of designing and improving fuel cell operated products. At Cellex, he developed several test jigs and integration/assembly instructions for the mass production of fuel cell products. He also participated in project management, part testing and product integration. In addition, Sarang has had extensive past experience managing the finances of small businesses.

8. Conclusion

MFC Labs is dedicated to the dream of achieving fuel cell power for portable electronics. We believe that micro fuel cell technology offers consumers the possibility of having truly portable devices with no reliance on power cables for recharging batteries. Micro fuel cells will provide the next step in the direction of creating truly portable electronics. Increased device portability will have profound impacts on fields ranging from information technology, construction, medical devices, entertainment, and military applications. Furthermore, micro fuel cells will provide portable electronics consumers with longer lifetimes than conventional portable power sources, decreasing waste due to the disposal of batteries. Providing a cheap and reliable micro fuel cell testbench is an important step in achieving the dream of commercializing micro fuel cells.

MFC Labs is dedicated to producing the MFC Testbench for NRC's micro fuel cell in order to speed up its time to commercialization. Our budget and timeline show that we have a realistic plan for achieving our goals. Furthermore, we have demonstrated that our proposed design can provide a reliable, easy to use, expandable and stand-alone solution for the MFC Testbench.

At MFC Labs, we believe in providing small innovations to big problems, and we take pride in the fact that our work has the potential to affect the lives of so many people.

9. References

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