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Testimony

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I would like to thank Chairman Brooks and Ranking Member Lipinski for inviting me to share my views on the NSF I-Corps Program.

I am an Assistant Professor in the Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign. I have spent the past 20 years studying optics and lasers and their applications in biomedicine. Recently, I have participated in the I-Corps program as the PI of our team, Phi Optics. The team included Entrepreneurial Lead Dr. Catalin Chiritescu and Business Mentor Tim Hoerr. Our participation in the I-Corps program has made a tremendous impact in the potential for success of Phi Optics. With the knowledge gathered during the program and adjustments we brought to the business model, we are now starting to seek seed investment. Recently, Phi Optics received the first order for the alpha-prototype from a major life sciences company. This fall, we will be visited by a world leading microscopy company, interested to partner and co-develop our technology into commercial products.

PI's experience as an I-Corps awardee

As a PI, I have learned a great deal during the program. For example, I learned that features of our technology are not synonymous with "value proposition". Thus, our team learned that we must develop a clear and compelling value proposition in order to gain traction from customers.

Business models need to be flexible and allow for pivoting – invariably, information will be gathered along the way that directs a start-up to change strategy and business approach. For example, our team ended up with two different business models depending on whether we team up with a strategic partner (large corporation) or not.

Interacting with 100 potential customers is an incredibly valuable experience, the results of which cannot be replicated in any other way. Prior to attending the program, I did not have a good appreciation of the two fundamental tasks in starting a business: business model development and customer development.

Overall, the striking feature of the program is that it offers a "scientific" approach to commercialization. Through interactions with potential customers, we have the opportunity to test certain hypotheses, e.g., what is the proper set of features for our product, how much should it cost, etc. This is precisely our approach in the laboratory, where, in order to understand a certain phenomenon, we perform experimental validation of various hypotheses.

Personally, I would like to see the I-Corps program expanded locally on campuses throughout the country. As an alumnus, I will be happy to help train new teams at University of Illinois.

Objectives and achievements of the I-Corps program

The program is one of the most effective uses of federal dollars that I have encountered in my professional career. It combines several key elements to produce a highly catalytic environment for the launch of technology start-ups. Those elements are (a) top-drawer entrepreneurial education from experienced, "real world" instructors, (b) significant interaction with potential users/customers of the subject technology/product, (c) maximum accountability to the teaching team and program peers. This combination of elements makes the I-Corps quite unique among federal programs, and should increase the odds of commercial success of the program participants.

Speaking on behalf of the Phi Optics team, I believe the program objectives were achieved. We evolved our business model throughout the process, refined our value proposition, and focused our go-to-market strategy. Perhaps the team would benefit from a more extended one-on-one interaction with the teaching team. This way, problems that are specific to particular teams could be discussed in more detail.

Benefit of the I-Corps program to the taxpayer

Technology commercialization is a lengthy and challenging process. Biomedical technology in particular must face intense scrutiny such as the FDA approval mechanism, which can often temper the enthusiasm of investors. Access to the talent and capital required for the early stage commercialization process (the "valley of death") is the main obstacle in the way of translating basic research to solving commercial needs.

For decades the National Science Foundation has been investing large amounts of funding in basic science, which continuously pushed the frontiers of our knowledge. The SBIR/STTR program has helped commercializing some of the technology developed through this research. I believe that the I-Corps Program is an extremely useful, pre-SBIR tool, for training the start-up teams and helping them validate the true commercial potential of the technology. As large industry looks to academia and small business, including "spin-out" companies, to fill product portfolios and identify new tools for efficiency, the I-Corps Program can act as a catalyzer and enhance the probability of commercial success.

The program provides an opportunity to validate the commercial potential of a technology, *before* significant investments from federal and private sources are committed. In essence, the probability of success for the projects going forward is maximized, while the losses due to the projects unlikely to succeed are minimized. The taxpayers receive a huge return from their investment. Successful commercialization of a technology creates wealth and jobs, while improving the life of the society at large, e.g., by providing better health care.

Background on the PI and Technology

After Bachelor's and Master's degrees in Physics pursued in my home country of Romania, 15 years ago I came to the United States for my PhD studies in Optics, focusing on the interaction between laser radiation and biological tissue. I pursued my postdoctoral studies at M.I.T., developing new imaging technologies for studying cells and tissues. In 2007 I joined the University of Illinois faculty and established the Quantitative Light Imaging Laboratory, which I direct at the Beckman Institute for Advanced Science and Technology. In 2004 I became a U.S. permanent resident via the "National Interest Waver" and in 2009 I received the U.S. citizenship.

My work in the field of Biomedical Optics resulted in one authored book, one edited book, 76 refereed articles, 84 invited lectures, 6 book chapters, 82 conference presentations, and 24 patents of inventions (9 more disclosures are being reviewed by the University). I am Associated Editor of lead journals in optics, Optics Express and Biomedical Optics Express, serve on the Editorial board of Journal of Biomedical Optics, and organized and presided sessions at several international conferences. I am enthusiastic about teaching: I developed a new graduate course at UIUC on Modern Light Microscopy (ECE 564) and upgraded the advanced undergraduate course on Optical Imaging (ECE 460). Over the past 4 years I founded and co-organized the Biophotonics Summer School at Urbana-Champaign, a two-week program sponsored in part by NSF, which has attracted students from the U.S. and many countries.

My research group at University of Illinois consists of a postdoctoral associate, 6 PhD students, and 5 undergraduate students. Our research has three components: *technology development*, *basic science* studies, and *clinical applications*. The motivation for this work can be briefly explained as follows. Most cells from our body do not absorb light significantly and thus are transparent under visible light. In order to study them, researchers typically label the cells with contrast agents, such as fluorophores and dyes. Thus, in the life sciences, fluorescence microcopy is the most commonly used form of microscopy. However, there are significant limitations associated with fluorescence: *photobleaching* limits the temporal window of opportunity for imaging before the molecules stop emitting light (or bleach); *phototoxicity* negatively affects or kills the cells due to the high exposure required and the short wavelength of the excitation light (typically in the UV range). Existing instruments are therefore destructive, inaccurate, labor-intensive, and expensive to operate. These technical limitations result in erroneous diagnoses of disease, slow drug discovery, and poor understanding of cellular function. Improved technology will generate early and accurate diagnosis, new cures for devastating diseases, and billions of dollars in wealth across several different markets, including in-vitro diagnosis ($44B market), Biotech R&D ($20B), Biopharma ($70B).

Phi Optics, Inc. develops disruptive light microscopy technology that is accurate, nondestructive (label-free), fast, and inexpensive. The innovation with respect to the state of the art stems from using two beams of light instead of just one: a portion of the light travels through the specimen and carries the information, while the second does not, i.e., it is used as *reference.* Measuring the superposition of the two beams, a principle known as *interferometry*, is extremely sensitive to subtle structural details in the sample, without the need for invasive contrast agents. As a result, the specimen preparation is greatly simplified and studies can be performed indefinitely, without limitations due to photobleaching and phototoxicity.

Our technology, referred to as *quantitative phase imaging (QPI)*, has been aggressively protected by the University of Illinois' Office of Technology Management: there are 15-20 disclosures, pending, and issued patents on this technology. The main patent, which protects the core Phi Optics technology, has been recently issued (Patent No. US 8,184,298, May 22, 2012).

Our QPI technology will improve human health at several different levels and contribute toward maintaining the US edge in the area of high-tech biomedicine. Specifically, if successfully commercialized, our new class of instruments will enable the following highly significant applications:

- Novel cancer drug discovery by accurate, label-free monitoring of cell response to treatment
- Automatic cancer diagnosis of biopsies and blood testing
- Basic understanding of cell function: differentiation, proliferation, and death
- Semiconductor testing with nanoscale accuracy

Due to its full automation, our diagnosis instrument can operate in areas with limited access to trained personnel and provide the digital data necessary for remote diagnosis. Our images are *quantitative*, meaning that there is no calibration necessary when operating the instrument at different sites. These features recommend our technology for applications of *global coverage*, such as screening for malaria in under-served populations of Southeast Asia and Africa.

Linage of the innovation

Our technological innovation is, to a large extent, the result of funding from the National Cancer Institute and two NSF grants. The brief description of these two research proposals are presented below.

2009 NSF CAREER Award: CBET 08-46660 "Quantitative phase imaging of cells and tissues" ($400K, 5 years).

The proposed research focuses on extending the boundaries of quantitative phase imaging (QPI) developed by the PI to high-impact applications, including neuroscience, cancer imaging, and cell membrane biophysics. QPI has the unique ability to quantify subtle changes in both structure and dynamics of cells and tissues, without using contrast agents. Imaging thin tissue slices, we are able to measure directly their refractive index distribution over broad areas, i.e. covering the entire organ. For the first time, we extracted a refractive index map at the organ scale which will serve the double purpose of both providing input parameters for modeling light-tissue interaction and also detect and monitor disease. Thus, the refractive index information will be correlated with the onset and development of breast cancer in a mouse model. QPI is a very powerful method for quantifying motions in cells at the nanometer scale. QPI sensitivity to nanoscale motions generated by minute refractive index changes in live neurons are exploited to understand how they function and communicate. Essentially, we treat the neurons in culture as a (complicated) circuit board and apply our non-contact, full-field, motion sensors to understand how the circuits work. All these research activities are developed in a highly collaborative manner with scientists from different departments on our campus and beyond, as indicated in the collaboration letters attached.

2010 NSF Major Instrumentation Grant from NSF: CBET 1040462 "Development of spatial light interference microscope (SLIM) for Materials and Life Sciences", ($2M including campus matching, 4 years).

This project aims at establishing a QPI facility for shared use at the Beckman Institute for both materials and life sciences. SLIM is a novel, highly sensitive QPI method, which promises to enable unprecedented structure and dynamics studies in biology and beyond. SLIM combines Zernike's PC method by revealing the intrinsic contrast of transparent samples, with Gabor's holography by rendering quantitative phase maps across the sample. Because of the extremely short coherence length of this illumination light, approximately 1.2 µm, SLIM provides label-free optical sectioning, allowing a three-dimensional view of live cells, which reflects the scattering potential distribution. Taken together, SLIM's features advance the field of quantitative phase imaging by several accounts: i) provides speckle-free images, which allows for spatially sensitive optical path-length measurement (0.3 nm); ii) uses common path interferometry, which enables temporally sensitive optical path-length measurement (0.03nm); iii) renders 3D tomographic images of transparent structures; iv) due to the broad band illumination, SLIM grants immediate potential for spectroscopic (i.e. phase dispersion) imaging;

v) is likely to make a broad impact by implementation with existing phase contrast microscopes; vi) and inherently multiplexes with fluorescence imaging for multimodal, in-depth biological studies. This quantitative phase imaging instrument will benefit diverse research efforts in the materials and life sciences. In particular, it will enable: (1) non-destructive inspection of nanostructures, semiconductor devices, and new materials such as graphene and carbon/semiconductor nanotubes, (2) observation of the dynamics of live cells and transport in neurons, and (3) exploration of new cancer detection techniques.

Working on these projects, especially on the QPI shared facility, the PI has been faced with many of the challenges associated with commercialization (e.g., ease of use, friendly user interface, computer-control automation). Most of these obstacles have been overcome and now we have in the lab a working prototype that can provide quantitative phase data over broad spatial and temporal scales using computer control.

The Phi Optics Team

In March 2012, the Phi Optics team was selected to participate in the I-Corps program. Our I-Corps team that traveled to Stanford for the Lean Launchpad course combines complementary expertise in biomedical imaging (PI), materials science (Entrepreneurial Lead), and business management (Business mentor), as follows.

Entrepreneurial Lead: Catalin Chiritescu. Dr. Chiritescu is a University of Illinois Ph.D. graduate from the Materials Science and Engineering Department (2010). He has a M.Sc. in Mechanical Engineering from University of Rochester, NY (2001) and one in Physics from University of Bucharest, Romania (1999). His past experience includes the UIUC Materials Research Laboratory in Urbana, IL (2002-2010), the Laboratory for Laser Energetics - OMEGA facility in Rochester, NY (2000-2001), the Institute for Laser, Plasma and Radiation Physics in Bucharest, Romania (1997-2000), and the Institute of Physics and Chemistry of Materials – CNRS in Strasbourg, France (1999). The majority of his research is in the field of nanoscale materials science and ultrafast optical spectroscopy and was published in 14 peer-reviewed and 3 conference papers. He served as reviewer for the Journal of American Chemical Society and the Journal of Applied Physics.

As a materials engineer Dr Chiritescu worked on applied research contracts with customers from the academia (Purdue University, UCSB, University of Manchester-UK), research labs (LANL, LLBL), and defense (ONR, AFOSR). Dr. Chiritescu joined Phi Optics Inc. in 2011 and serves as CTO by spearheading the development of QPI and related technology applications in the nanotechnology and materials science fields. He is also responsible for the day-to-day operations of the company.

Business Mentor: Tim Hoerr is a seasoned business executive with over 28 years of experience spanning a variety of industries. Tim is the Managing Partner of Serra Capital and CEO of Serra Ventures, LLC, a professional services firm offering assistance in business strategy, capital formation, transitional executive leadership, and organization development. He also serves as transitional CEO of Cbana Labs, a start-up technology venture located in the University of Illinois Research Park, Champaign, Illinois. Tim serves the University of Illinois technology community in the role of Entrepreneur-in-Residence at EnterpriseWorks business incubator in the Research Park. In February, 2009, Tim received the Entrepreneurial Excellence in Management Award at the Innovation Celebration ceremony sponsored by the University of Illinois and Champaign County Economic Development Corporation.

For nearly seven years, from mid-2001 through 2008, Tim served in the capacity of Co-Founder and CEO of iCyt, a rapidly growing bioscience technology firm located in the University of Illinois Research Park. iCyt provides state of the art instruments, reagents and service to global clients in the field of cytometry, the science of cell measurement. iCyt has won numerous awards including Best Places to Work in Illinois (2007, 2008) and the Frost & Sullivan Emerging Technology Award (2008). iCyt was acquired by Sony Corporation in late 2009.

Since 1983 he has assisted over 400 organizations to achieve high performance by providing strategic, operational and leadership consulting. Tim spent nearly all of the first 15 years of his professional career with RSM McGladrey, the fifth largest international CPA and Consulting firm. He served in offices located in Illinois and San Diego, leading teams of consultants focused on serving middle market clients. In his capacity as Consulting Partner with McGladrey, Tim provided leadership on a regional and national level. He also served on two national committees for the American Society of Certified Public Accountants (Business Valuation and Emerging Services).

Principal Investigator: Gabriel Popescu.