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**14. ABSTRACT**
Work under this center grant consisted of 9 projects directed toward the development and translation of biomedical photonics technologies to address Joint Force Health Protection (JFHP) capability gaps for combat trauma and critical care that have been identified by the Secretary as requiring medical R&D. These efforts include Diffuse Optical Spectroscopy (DOSI) detection for hemorrhagic shock, cytochrome c oxidase, and dehydration; Optical Coherence Tomography (OCT) and Multiphoton Microscopy (MPM) for evaluation of airway injury; Spatial Frequency Domain Imaging (SDFI) and Laser Speckle Imaging (LSI) for imaging of burns, wounds and reconstructive surgery; a continuous, real time, minimally invasive Lactate/pCO2/pO2 patient sensor; and assessment of nitrosyl-cobinamide with and without low level light therapy for acceleration of wound healing.

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# ADVANCED OPTICAL TECHNOLOGIES FOR DEFENSE TRAUMA AND CRITICAL CARE

**MICHAEL BERNS**

**UNIVERSITY OF CALIFORNIA, IRVINE**

**02/04/2014**
**Final Report**

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**AIR FORCE RESEARCH LABORATORY**
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# Final Performance Report

**PRINCIPAL INVESTIGATOR: Michael W. Berns, Ph.D.**

**INSTITUTION: University of California, Irvine**

**GRANT TITLE: Advanced Optical Technologies for Defense Trauma and Critical Care**

**PERIOD: 30 September 2010 – 30 November 2013**

**GRANT NUMBER: FA9550-10-1-0538**

The following projects were conducted with funding under this grant:

## Inhalation Airway Injury: High-Resolution OCT Imaging and Clinical Evaluations (Brenner)

### Objectives

The specific objectives of this proposal were to:

1. Determine the capability of the prototype ultra-fast long-range OCT platform to obtain high quality, high resolution images down the length of the trachea in the rabbit smoke inhalation animal model and visualize smoke induced changes.

2. Determine the capability of this prototype to obtain high-quality images within the large lumen of excised pig and human tracheas, with visualization around the entire circumference of the airway, and high resolution visualization of subsurface tissue layers (with histologic co-registration validation).

3. To further validate these capabilities in-vivo in large animal pig studies, demonstrating good resolution in the face of respiratory and cardiac motion.

4. Demonstrate *user-friendly* image acquisition capabilities (use by non-technical personnel).

5. Deliver a clinical system to USAISR for clinical patient studies using the ultra-fast long-range OCT system.

## Accomplishments

We have demonstrated the ability of our ultrafast three-dimensional OCT airway imaging platform to accurately assess the extent of airway injury during acute smoke inhalation and battlefield relevant combined acute smoke/cyanide exposures, including:

1. Determined the capability of the prototype ultra-fast long-range OCT platform to obtain high quality, high resolution images down the length of the trachea in the rabbit smoke inhalation animal model and visualize smoke induced changes.

2. Determined the capability of this prototype to obtain high-quality images within the large lumen of excised pig and human tracheas, with visualization around the entire circumference of the airway, and high resolution visualization of subsurface tissue layers (with histologic co-registration validation).

3. Demonstrated user-friendly image acquisition capabilities (use by non-technical personnel).

Studies were completed to provide a characterization of early pathological changes, extent and injury progression associated with smoke inhalation injury and concomitant cyanide poisoning. The model system was designed to mimic conditions found in battlefield and other smoke inhalation scenarios. A high resolution, swept source, 3D MEMS motor-based OCT probe was used to perform circumferential scanning of the trachea and document progression of injury. In addition, diffuse optical spectroscopy (DOS) and continuous wave near infrared spectroscopy were used to monitor the physiological consequences of cyanide poisoning progression, including oxy- and deoxyhemoglobin and cytochrome c oxidase concentrations during the smoke exposure and cyanide infusion. Separation of cytochrome c oxidase redox states from deoxyhemoglobin was achieved by DOS. OCT images were able to document and quantify progression of thickening of the mucosal layer. DOS and CWNIRS were able to track the progressive effects of cyanide on physiology. Experiments have been completed to date to include controls, changes due to smoke exposure alone, the combination of smoke and CN exposure. Completed studies on the effect of cobinamide reversal of cyanide poisoning in this smoke model are undergoing analysis currently. Rabbit studies have now been completed for the OCT airway imaging development program. OCT Medical, Inc., a company formed to commercialize the OCT technology developed at BLI, has traveled to USAISR to demonstrate the OCT technology and interface in the pig and sheep models of airway injury. User interface comments and input were obtained at each experiment, and changes were made in response. A joint OCT Medical/BLI/USAISR manuscript of this work has been submitted for publication and is currently under review.

Student Theses: None

## Development of High Speed Long-Range Fourier Domain OCT for Imaging Combat Injuries and Wound Healing (Chen)

### Objectives

Smoke inhalation injury remains a major threat to military personnel, representing a complicating factor in 10–20% of military burn patients, and was reported in 27% of all GWOT admissions in 2007. The objective of the project is to develop a high-speed long-range Fourier domain OCT system for imaging combat injury and wound healing of inhalation airway injury. The goal is to accelerate the translation and clinical development of this platform technology by demonstrating the ability of this technology to assess response to therapy in large animal models.

### Accomplishments

We have successfully developed a fully functioning prototype of the long-range OCT system in conjunction with OCT Medical Imaging Inc., a start-up company that licenses OCT technology from UCI. The interferometry unit is a compact and fully integrated optical system that includes an acousto-optic modulator (AOM) to generate a carrier frequency on the OCT signal, allowing us to utilize full coherence length of the swept laser source and achieve approximately 25 mm imaging range. During image acquisition, the OCT probe driving unit rotates the probe at 1500 rpm to achieve 25 cross section images per second while pulling the probe back at 12.5mm/s, allowing us to image a 3D volume with a maximum length of 20 cm (mechanical limit) in just 16 seconds.

The system was tested in rabbit model of smoke inhalation injury in our laboratory and then the unit was transported to USAISR where we demonstrated the capabilities of long-range swept-source OCT to image and detect airway changes following smoke inhalation in a large animal model of severe burns and smoke inhalation. Measurements of airway thickness were performed at baseline and post injury and mucosal thickness changes following smoke inhalation is observed.

Student Theses: None

## Wound Healing Systems to Assay and Mitigate Airway Injury (Berns)

### Objectives

The goal of this project was to develop a chemical/optical method that would accelerate wound healing in military personnel. The specific aims were to:

1. Understand how Nitrosyl-Cobinamide (NO-Cbi) accelerates wound healing at optimal doses in cell models;

2. Use our photonic-based wound healing models to compliment the in-vivo diagnostic 3D-OCT airway imaging assessment of wound damage and healing.

3. Apply our wound healing results from the NO donor, NO-Cbi in-vitro studies in future in-vivo studies on early smoke inhalation airway injury with the effectiveness of this intervention assessed using OCT

### Accomplishments

1. We have characterized the new nitric oxide (NO) donating drug nitrosyl-cobinamide (NO-Cbi), which improves wound healing in-vitro in several different cell systems, including lung epithelial cells and primary human lung fibroblasts.

2. On a molar basis, NO-Cbi was more effective than two other NO donors, with the effective NO-Cbi

dose ranging from 3 to 10 μM, depending on the cell type.

3. We established an optimal dose range working in collaboration with the UCI inhalation airway group in order to provide useful dose parameters for application to airway and skin.

4. Mechanistically, we observed that improved wound healing was from increased cell migration and not cell proliferation (division). We found that the effect of NO-Cbi was mainly through cGMP-dependent protein kinase G (PKG) type I, as determined using pharmacological inhibitors and activators, and siRNAs targeting PKG type I and II. It was also determined that Src and ERK were two downstream mediators of NO-Cbi's effect. We conclude that NO-Cbi is a potent inducer of cell migration and wound closure, acting via cGMP, PKG, Src and ERK.

5. We published a major paper on this work in the journal *Cell Signaling* (5:2374–2382, 2023), filed a provisional patent on an invention from this project, and through UC Irvine have licensed the invention to a company that proposes to commercialize the invention specifically for wound healing. The company also provided graduate fellowship funds to supplement the funds provided by this grant. In addition, the results of preliminary studies combining NO-Cbi with low level light therapy (LLLT) suggest the combination of the two approaches is synergistic, resulting in more rapid wound healing than either alone.

Student Theses: In progress

## Fiberoptic Imaging Probe for In-vivo Detection and Monitoring of Smoke and Chemical Agent Injuries of the Upper Airways (Wilder-Smith)

### Objectives

The objective of this project was to design, optimize and package a bench-top fiberoptic non-linear optical microscopy (NLOM) imaging system to detect, quantify and better understand upper airway inhalation injury. Our previous data determined that use of such a capability in the easily accessible naso-pharynx serves as an accurate indicator of the status of the entire airway [4]. The proposed NLOM modality allowed acquisition of three-dimensional high-resolution structural images of tissue, without using external stains, from both two photon fluorescence (TPF) and second harmonic generation (SHG) signals of tissue constituents [2,3]. In the later stages of the project, Raman and SRS features were additionally incorporated into the system [1,5].

**Accomplishments**

Over the course of this project we have:

1. Completed complex ZEMAX modeling to design a compact low-cost multi-component lens with performance similar to that of a high-cost single custom-fabricated lens.

2. Constructed, tested, and optimized this lens assembly.

3. Developed software for image acquisition.

4. Developed and validated a novel micro-scanning mechanism for the miniature probe head.

5. Imaged ex-vivo tissue specimens.

**Student Theses:** Richa Mittal Doctoral Thesis: Towards in vivo Nonlinear Optical Microscopy.

**References:**

1. Mittal R, Balu M, Liu G, Chen Z, Tromberg B, Wilder-Smith P and Potma E. A minimally-invasive approach to the challenge of oral neoplasia. American Society for Laser Medicine and Surgery (ASLMS) Annual Conference, 2013, Boston, Oral Presentation
2. Mittal R, Balu M, Liu G, Chen Z, Tromberg B, Wilder-Smith P and Potma E. Development of a coherent Raman scattering fiber probe SPIE, Photonics West, 2013, San Francisco, Oral Presentation
3. Mittal R, Balu M, Liu G, Chen Z, Tromberg B, Wilder-Smith P and Potma E. Design of a coherent Raman scattering fiber optic probe and its application to biomedical imaging. International Conference on Raman Spectroscopy (ICORS), 2012, Bangalore, India, Poster
4. Hammer-Wilson MJ, Nguyen V, Jung WG, Ahn Y, Chen Z, Wilder-

Smith P. Detection of Vesicant-induced Upper Airway Mucosa Damage in the Hamster Cheek Pouch Model Using Optical Coherence Tomography. J. Biomed. Opt. 15: 016017, 2010. PMCID 2839801

5. Mittal R, Balu M, Wilder-Smith P, Potma EO. Achromatic miniature lens system for coherent Raman scattering microscopy. Biomedical Optics Express 4: 2196-2206, 2013.

## Concurrent Continuous Lactate Monitoring *AND* DOS Monitoring of Cytochrome c Oxidase Redox States for Hemorrhage Resuscitation, Cyanide Poisoning and Smoke Inhalation (Brenner)

**Objectives:**

The goals of this project were to demonstrate feasibility of the concept of DOS monitoring of CcO redox state using a) smoke inhalation injury/CN toxicity and treatment protocol, and b) the hemorrhage and hypovolemic resuscitation treatment protocol in New Zealand White rabbits, and to test the continuous lactate sensor developed by Dr. Elliot Botvinick in-vivo in the rabbit model of cyanide poisoning.

**Accompishments:**

1. Non-invasive in-vivo DOS measurements of tissue oxygenation status and CcO redox states followed the physiological changes resulting from smoke inhalation injury/CN toxicity and treatment, and were also obtained in animals during hemorrhage and resuscitation.

2. The unique absorbance signatures of the oxidized and reduced metal centers in CcO allowed us to monitor CcO redox states using DOS in animals in the smoke and cyanide injured animals as well as in hemorrhaged and resuscitated animals. CcO redox state ratio became reduced during cyanide poisoning. This was also the case during progressive hemorrhage, concomitant to a decrease in oxyhemoglobin. A manuscript has been submitted, and is being revised for publication based on reviewers' comments.

3. The continuous lactate sensor, a 0.5 mm device, is placed by subcutaneous injection. The sensor has been placed in rabbits in more than 20 smoke/CN experiments, and has been shown to track lactate

levels consistently with blood lactate levels as they change during cyanide exposure.

4. DOS, along with SFDI-MI and LSI devices were taken to USAISR in San Antonio during 2012, and were used during a number of pig hemorrhage studies under 2 different hemorrhage protocols. This collaborative work was presented at MHSRS 2013 by Dr. J.S. Berry of USAISR.

Student Theses: None

## Monitoring Tissue Hydration And Physiologic Status Using Diffuse Optical Spectroscopy For Detection Of Dehydration (Brenner)

### Objectives

This project was designed to evaluate the feasibility of using DOS to monitor hydration by manipulating the hydration status of animal subjects using 5% dextrose water (D5W). The goals of this study were to:

1. Determine the sensitivity of DOS water concentration measurements to gauge overall hydration status,

2. Measure potential changes in other DOS parameters (e.g. hemoglobin concentrations, tissue oxygenation, and lipid content) associated with changes in tissue water content and ultimately hydration status,

3. Define the quantitative correlation between hydration status and DOS tissue water measurements over a range of dehydration and rehydration levels in animal models, and

4. Demonstrate and validate the capability of non-invasive DOS technologies to monitor hydration status by measuring tissue water concentration during acute dehydration in humans during marathon running events.

### Accomplishments

Water was withheld for 24 hours in 18 rabbit subjects, resulting in approximately 5% loss of body weight. DOS monitoring performed during intravenous rehydration with 60cc of D5W was able to detect a change in water content of 0 to >4% during the course of rehydration. This finding demonstrated the feasibility of DOS for hydration status monitoring. Studies and data analysis are now underway which include more pronounced dehydration and rehydration steps, in order to complete DOS correlations and to further correlation with other DOS-determined tissue parameters. These studies will continue in the next year. An IRB protocol to use DOS and SFDI-MI monitoring to examine detection of dehydration in individuals training for marathons in Southern California has been approved by the UCI IRB, was submitted to the Air Force Surgeon General's Office for approval in September, 2013, and final approval is awaited before studies begin.

Student Theses: None

## Advanced Surgical Camera For Imaging Traumatic Wounds And Reconstructive Surgery (Durkin)

### Objectives

The objectives of this project were to develop spatial frequency domain imaging (SFDI) for applications in trauma, reconstructive surgery, wound healing and evaluation of burn severity. This work involved continued SFDI technology development and advancing our knowledge of SFDI with respect to in-vivo data collection and interpretation, both in preclinical animal models and human subjects, including:

1. Develop and validate a "clinic friendly" SFDI device capable of rapidly and quantitatively measuring in-vivo wide-field structure and function.

2. Develop and refine computational models with particular attention given to a) rapid, near-real time data analysis and b) accounting for the effects of melanin on hemodynamic parameters.

3. Collection of in-vivo SFDI data from rat, pig and human tissues, including burn wounds.

**Accomplishments**

1. In collaboration with commercial partner, Modulated Imaging Inc., developed a SFDI device based on LED light sources capable of quantitatively measuring wide-field (10 cm x 13 cm) concentration of oxy & deoxyhemoglobin, total hemoglobin, oxygen saturation, water and scattering (related to tissue structure).[1, 2]

2. Validated LED based SFDI performance using tissue simulating phantoms and blood based liquid phantoms.[2]

3. Developed approaches for ameliorating the effects of melanin on hemodynamic parameters, however these approaches generally require a greater number of wavelengths than are provided by the LED based SFDI system.[3, 4]

4. In collaboration with our commercial partner, Modulated Imaging Inc., we deployed the LED based SFDI system to USAIR in order to demonstrate basic instrument functionality and near-real-time analysis capabilities in an in-vivo porcine hemorrhage model.

5. In collaboration with Nicole Bernal (MD, UCI Burn Center) and the Choi lab (laser speckle imaging), using a rat model of graded burn severity, determined that SFDI has potential as a burn-wound monitoring system and may have predictive capabilities of burn-wound outcome.[5, 6]

6. In conjunction with the Choi lab (LSI), conducted studies using LSI and SFDI to characterize optical signatures associated with different degrees of burn severity in a pig model in collaboration with Robert Christy at USAISR. Results suggest that reduced scattering coefficient may predict burn severity within hours of the burn event. [7]

**References**

1. Mazhar, A., et al., Lasers Surg Med, 2012. **44**(8): p. 611-21.
2. Mazhar, A., et al. *Implementation of an LED-based clinical spatial frequency domain imaging system*. in *Photonics West*. 2012. San Francisco, CA: SPIE.
3. Yudovsky, et al., J Biomed Opt, 2012. **17**(10): p. 107006.
4. Yudovsky, D. et al,. J Biomed Opt, 2011. **16**(10): p. 107005.
5. Nguyen, J.Q., et al., J Biomed Opt, 2013. **18**(6): p. 66010.

6. Nguyen, J., et al. *Quantitative Longitudinal Measurement in a Rat Model of Controlled Burn Severity Using Spatial Frequency Domain Imaging* in *SPIE Photonics West/Bios*. 2013. San Francisco: SPIE.
7. Ponticorvo, A., et al., *Quantitative assessment of graded burn wounds in a porcine model using spatial frequency domain imaging (SFDI) and laser speckle imaging (LSI)*, in *Photonics West*2014: SPIE, San Francisco.

Student Theses: None

## Rapid Characterization And Whole Body Mapping Of Burn Wounds With Laser Speckle Imaging (Choi)

### Objectives

1. Characterize first-generation mcLSI instrument build

2. Collect pilot mcLSI data from UC-Irvine Regional Burn Center

### Accomplishments

During the funding period, we accomplished the following results related to the scope of the project:

1. Developed an imaging method, multi-camera laser speckle imaging (mcLSI), that consists of multiple Laser Speckle Imaging modules and includes concepts of image stitching. Our results demonstrate that, with mcLSI, we acquired images with a larger field of view, a larger range of speckle contrast, and a higher spatial resolution compared to conventional LSI. We also demonstrated that mcLSI enables improved characterization of curved surfaces of the body by positioning LSI modules at different angles. We expect that extension of this method will enable imaging of skin blood flow over large regions of the body. This was included in a thesis by Yu-Shan Hsiao.

2. We developed a battery-powered LSI device, that we call mobile LSI (mLSI) and that enables noninvasive imaging of skin blood flow with a portable device. The device enables untethered blood-flow mapping at VGA resolution at a frame rate of 3 fps, for up to four hours. This work was included in a dissertation by Dr. Hyeoungho Bae. A manuscript is in preparation.

3. We worked with Dr. Tony Durkin's group to image blood flow in rats following burn injury of varying severity. We used both Spatial Frequency Domain Imaging (SFDI) and LSI modalities. We published the SFDI work in *Journal of Biomedical Optics* (Nguyen J et al., Vol. 18, article 066010, 2013). A manuscript describing the LSI results, is in preparation.

4. We worked with Drs. Tony Durkin and Bob Christy (USAISR, Ft. Sam Houston, TX) groups to image blood flow in pigs following burn injury of varying severity. We used both Spatial Frequency Domain Imaging (SFDI) and LSI modalities. A manuscript is in preparation.

5. We used LSI to measure blood flow dynamics in two preclinical models of hemorrhage: rabbit (with Dr. Matt Brenner's group) and pig (with Dr. Andriy Batchinsky's group, USAISR). We currently are preparing two manuscripts to describe our results.

**Student Theses:**

1. Hyeoungho Bae - "Embedded Computer Vision Systems for Image Based Motion and Speckle Image Analysis", Ph.D. dissertation, June 2013.

2. Yu-Shan Hsiao - "Multi-camera Laser Speckle Imaging System Implementation", M.S. thesis, June 2013.

## Development Of A Transcutaneous Continuous Lactate Monitor (Botvinick)

### Objectives

The goals of this study were to:

1. Determine optimal design parameters of a continuous lactate monitor. Specifically to determine the proper enzyme loading and device geometry to maintain lactate sensitivity across the clinical range as assessed in-vitro.

2. Demonstrate in-vivo device accuracy in rabbit studies.

**Accomplishments**

1. Developed, built, and verified a laboratory-grade portable test system to optically probe oxygen and lactate sensors implanted in subcutaneous tissue.

2. Tested tissue oxygen sensors in-vivo in rabbit cyanide poisoning model using in-vitro calibration to calculate $pO_2$ levels. Sensors have high signal-to-noise and accurately measure oxygen levels throughout the clinical range.

3. Manufactured micro-patterned implantable lactate sensors. Each sensor is approximately the size of a single long-grain rice kernel and is implanted subcutaneously by injection with a needle. Sensors are probed wirelessly by the portable test system in (1).

4. Tested lactate sensors in-vivo. Sensors were implanted in over 20 animals in the rabbit cyanide poisoning model. Most sensors have high signal-to-noise, and can track tissue lactate levels. Signals correspond well to blood lactate reference measurements.

5. A prototype of a miniaturized test system was constructed (about the size of a postage stamp): Lactate and oxygen concentrations were measured in a rabbit model using a custom-built miniature phosphorescent lifetime measurement system. Critical components of the system (excitation source and photodetector) were designed to support a product form factor that is small enough to be worn continuously by patients.

6. Oxygen concentration in the reference channel of the sensor was acquired concurrently with lactate concentration using spectrally separated phosphorescent dyes in concert with a dual-wavelength phosphorescent lifetime measurement system.

Student Theses: None

**PUBLICATIONS (2010–2013)**

1. Baker, N. M., Zeitlin S. G., Shi L. Z., Shah J., Berns M. W. Chromosome tips damaged anaphase inhibit cytokinesis. PLoS ONE 5(8):e12398.doi:10.1371/journal.pone.0012398 (2010).

2. Duquette, M. L., Q. Zhu, E. R. Taylor, A. J. Tsay, L. Z. Shi, M. W. Berns and C. H. McGowan. CtIP is required to initiate replication-dependent interstrand crosslink repair. PLoS Genet. 2012 Nov;8(11):e1003050. doi: 10.1371/journal.pgen.1003050. Epub 2012 Nov 8.

3. Ferraro-Gideon, J., R. Sheykhani, Q. Zhu, M. L. Duquette, M. W. Berns and A. Forer. Measurements of forces produced by the mitotic spindle using optical tweezers. Molecular Biology of the Cell 24: 1375-1386, 2013.

4. Forer, A., J. Ferraro-Gideon J and M. Berns. Distance segregation of sex chromosomes in crane-fly spermatocytes studied using laser microbeam irradiations. Protoplasma. 2013 Jan 13. [Epub ahead of print]

5. Gomez-Godinez, V., Wu, T., Sherman, A. J., Lee C. S., Liaw L.-H., Zhongsheng, Y., Yokomori, K., Berns, M.W. Analysis of DNA double-strand break response and chromatin structure in mitosis using laser microirradiation. Nucleic Acids Res. 1-18,doi:10.1093/nar/gkq836 (2010).

6. Hammer-Wilson, M. J., Nguyen, V., Jung, W. G., Ahn, Y. C., Chen, Z., Wilder-Smith, P. Detection of vesicant-induced upper airway mucosa damage in the hamster cheek pouch model using optical coherence tomography. J Biomed. Opt. 15: 016017 (2010).

7. Jing, J., J. Zhang, A. C. Loy, B. J. F. Wong, Z. Chen, "High-speed airway imaging using full-range optical coherence tomography," J. of Biomedical Optics 17, 110507 (2012).

8. Kaiser, M., Yafi, A., Cinat, M., Durkin, A. J. Noninvasive assessment of burn wound severity using

optical technology: a review of current and future modalities. Burns 37: 377-386 (2011).

9. Kim, C. S., W. Qi, J. Zhang, Y. J. Kwon, and Z. Chen, "Imaging and quantifying Brownian motion of micro- and nanoparticles using phase resolved Doppler variance optical coherence tomography," J. of Biomedical Optics 18, 030504-1 (2013).

10. Kim, J. G., Lee, J., Mahon, S. B., Mukai, D. S., Patterson, S. E., Boss, G. R., Tromberg, B. J., Brenner, M. Noninvasive monitoring of treatment response in a rabbit cyanide toxicity model reveals differences in brain and muscle metabolism. J. Biomed. Optics 17:10 105005, Oct. 2012.

11. Konecky, S. D., Rice, T. B., Durkin, A. J., Tromberg, B. J. Imaging scattering orientation with spatial frequency domain imaging. J Biomed. Optics 16: 126001 (2011).

12. Lee, S.-W., Heidari, A. E., Yoon, D., Mukai, D., Ramalingam, T., Mahon, S., Yin, J., Jing, J., Liu, G., Chen, Z., Brenner, M. Quantification of airway thickness changes in smoke-inhalation injury using in-vivo 3-D endoscopic frequency domain optical coherence tomography. Biomed Opt. Express 2: 243-254 (2011).

13. Li, J., J. Yin, X. Li, J. Jing, D. Mukai, S. Mahon, A. Edris, K. Hoang, K. K. Shung, M. Brenner, J. Liang, S. A. Saidi, J. Jing, G. Liu, J. Li, J Zhang, C. Sun, J. Narula, Z. Chen, "Intravascular atherosclerotic imaging with combined fluorescence and optical coherence tomography probe based on a double-clad fiber combiner," J. Biomed. Optics 17, 070501 (2012).

14. Li, J., J. Yin, X. Li, J. Jing, D. Mukai, S. Mahon, A. Edris, K. Hoang, K. K. Shung, M. Brenner, J. Narula, Q. Zhou, P. Patel, Z. Chen. Miniature integrated optical coherence tomography (OCT) – ultrasound probe for intravascular imaging. Photonic Therapeutics and Diagnostics VIII, edited by Nikiforos Kollias, et al., Proc. of SPIE Vol. 8207, 82073X© 2012 SPIE · CCC code: 1605-7422/12 · doi: 10.1117/12.905707

15. Lin, J. L., A. Y. Yau, J. Boyd, A. Hamamoto, E. Su, L. Tracy, A. E. Heidari, A. H. Wang, G. Ahuja, Z. Chen, B. J. Wong, "Real-Time Subglottic Stenosis Imaging Using Optical Coherence Tomography in the Rabbit," JAMA Otolaryngol. Head Neck Surg. 139, 503-8 (2013).

16. Liu, G., W. Jia, V. Sun, B. Choi and Z. Chen, "High-resolution imaging of microvasculature in human skin *in-vivo* with optical coherence tomography," Optics Express 20, 7694-7705 (2012).

17. Liu, G., A. J. Lin, B. J. Tromberg, and Z. Chen, "A comparison of Doppler optical coherence tomography methods," Biomedical Optics Express, 3, 2670 (2012).

18. Liu, G., and Z. Chen, "Advances in Doppler OCT," Chinese Optics Letter 11, 011702 (2013).

19. Liu, G., and Z. Chen, "Capturing the vital vascular fingerprint with optical coherence tomography," Applied Optics 52, 5473-7 (2013).

20. Liu, G., L. Chou, W. Jia, W. Qi, B. Choi, Z. Chen, "Intensity-based modified Doppler variance algorithm: application to phase instable and phase stable optical coherence tomography systems," Optics Express, Vol. 19, pp.11429-11440 (2011).

21. Liu, G., W. Jia, S. Nelson, Z. Chen, "*In-vivo*, high-resolution, three-dimensional imaging of port wine stain vasculature in human skin," Lasers in Surgery and Medicine 45: 628-632 (2013).

22. Liu, G., W. Jia, V. Sun, B. Choi, Z. Chen, "High-resolution imaging of microvasculature in human skin in-vivo with optical coherence tomography," Optics Express, 20, 7694-7705 (2012).

23. Mazhar, A., Dell, S., Cuccia, D., Gioux, S., Durkin, A., Frangioni, J., Tromberg, B. Wavelength optimization for rapid chromophore mapping using spatial frequency domain imaging (SFDI). J Biomed. Optics 15: 061716 (2010).

24. Mazhar, A., Sharif, S. A., Saggese, S., Cuccia, D.J., Choi, B., Durkin, A. J. Implementation of an LED based clinical spatial frequency domain imaging

system. Proc SPIE Vol. 8254, Emerging Digital Micromirror Device Based Systems and Applications IV, 82540A (February 9, 2012).

25. Mazhar, A., S. A. Sharif, D. J. Cuccia J. S. Nelson, K. M. Kelly and A. J. Durkin, Spatial Frequency Domain Imaging of Port Wine Stain Biochemical Composition in Response to Laser Therapy: A Pilot Study, Laser in Surgery and Medicine. 2012 Aug 21. doi: 10.1002/lsm.22067. [Epub ahead of print]

26. Mazhar, A., D. Cuccia, T. Rice, S. Carp, A. Durkin, D. Boas, B. Choi, B. Tromberg, "Laser speckle imaging in the spatial frequency domain," Biomedical Optics Express, Vol. 2, No. 6, pp.1553-1563 (2011).

27. Mittal, R., Balu, M., Wilder-Smith, P., Potma, E. O. Achromatic miniature lens system for coherent Raman scattering microscopy. Biomedical Optics Express 4: 2196-2206, 2013.

28. Nadeau, K. P., P. Khoury, A. Mazhar, D. J. Cuccia, A. J. Durkin, Component and system evaluation for the development of a handheld point-of-care spatial frequency domain imaging (SFDI) device BiOS, SPIE Photonics West, Feb 2013. Proc. SPIE 8573, Design and Quality for Biomedical Technologies VI, 857304 (March 13, 2013); doi:10.1117/12.2004909.

29. Nguyen J., Saager R. B., Cuccia D.J., Hsiang D., Kelly K. M., Durkin A. J. Effects of motion on optical properties in the spatial frequency domain. J Biomed Opt 16: 126009 (2011).

30. Nguyen, J. Q. M., T. Mai, C. Crouzet, N. Bernal, B. Choi, A. J. Durkin, Quantitative Longitudinal Measurement in a Rat model of Controlled Burn Severity Using Spatial Frequency Domain Imaging, Paper 8565-28, BiOS, SPIE Photonics West, Feb 2013. Proc. SPIE 8565, Photonic Therapeutics and Diagnostics IX, 85650S (March 8, 2013); doi:10.1117/12.2004894.

31. Nguyen, J. Q. M., C. Crouzet, T. Mai, K. Riola, D. Uchitel, L.-H. Liaw, N. Bernal, A. Ponticorvo, B. Choi, A. J. Durkin. Spatial frequency domain imaging of burn wounds in a preclinical model of

graded burn severity. Journal of Biomedical Optics, Vol. 18, No. 6, article 66010 (2013).

32. Pharaon, M. R., Scholz T., Bogdanoff S., Cuccia D., Durkin A. J., Hoyt D. D., Evans G. R. D. Early detection of complete vascular occlusion in a pedicle flap model using quantitative spectral imaging. Plastic & Reconstructive Surgery 126: 1924-1935 (2010).

33. Qi, W., R. Chen , L. Chou , G. Liu, J. Zhang, Q. Zhou, Z. Chen, “Phase-resolved acoustic radiation force optical coherence elastography,” J. of Biomedical Optics 17, 110505, (2012).

34. Qi, W., R. Li, T. Ma, J. Li, G. Liu, J. Zhang, Q. Zhou, Z. Chen, “Resonant Acoustic Radiation Force Optical Coherence Elastography,” Applied Physics Letter 103,103704 (2013).

35. Rice, T. B., E. Kwan, C. Hayakawa, A. J. Durkin, B. Choi, B. J. Tromberg. Quantitative, depth-resolved determination of particle motion using multi-exposure, spatial frequency domain laser speckle imaging. Biomedical Optics Express, Vol. 4, No. 12, pp. 2880-2892 (2013).

36. Rice, T., S. Konecky, A. Mazhar, D. Cuccia, A. Durkin, B. Choi, B. Tromberg, " Quantitative determination of dynamical properties using coherent spatial frequency domain imaging", Journal of the Optical Society of America A, Vol. 28, No. 10, pp.2108-2114 (2011).

37. Rice, T., S. Konecky, C. Owen, B. Choi, B. Tromberg, "Determination of the effect of source intensity profile on speckle contrast using coherent spatial frequency domain imaging," Biomedical Optics Express, Vol. 3, pp.1340-1349 (2012).

38. Saager R. B., Truong A, Cuccia D. J., Durkin A. J. Method for depth-resolved quantitation of optical properties in layered media using Spatially Modulated Quantitative Spectroscopy (SMoQS). Journal of Biomedical Optics 16: 077002 (2011).

39. Sharif, S. A., R. Rahimian, E. Taydas, A. Mazhar, B. Choi, K. M. Kelly and A. J. Durkin, Noninvasive

clinical assessment of port-wine stain birthmarks using current and future optical imaging technology: A review, Br. J. Dermatol. 2012 July 14. doi: 10.1111/j.1365-2133.2012.11139.x.

40. Sheykhani, R., N. Baker, V. Gomez-Godinez, L.-H. Liaw, J. Shah, M. W. Berns and A. Forer. The role of actin and myosin in PtK2 spindle length changes induced by laser microbeam irradiations across the spindle. Cytoskeleton 70: 241-259, 2013.

41. Shi, L. Z., Q. Zhu, T. Wu, M. Duquette, V. Gomez, C. Chandsawangbhuwana, M. S. Harsono, N. Hyun, N. Baker, J. Nascimento, Z. You, E. B. Botvinick and M. W. Berns. Integrated optical systems for laser nanosurgery and optical trapping to study cell structure and function. In: Current Microscopy Contributions to Advances in Science and Technology, A. Mendez-Vilas (ed.). Badajoz, Spain: Formatex, Microscopy Book Series – Number 5, 2012.

42. Shi, L. Z., Q. Zhu, T. Wu, M. L. Duquette, V. Gomez, C. Chandsawangbhuwana, M. S. Harsono, N. Hyun, N. Baker, J. Nascimento, Z. You, E. B. Botvinick and M. W. Berns, Integrated Optical Systems for Laser Nanosurgery and Optical Trapping to Study Cell Structure and Function. In: Current microscopy contributions to advances in science and technology, Antonio Méndez-Vilas(ed.). Formatex Research Center, Volume 1 ISBN (13): 978-84-939843-5-9, Publication date: December 2012.

43. Silva, B. A., J. R. Stambaugh and M. W. Berns. Targeting telomere-containing chromosome ends with a near-infrared femtosecond laser to study the activation of the DNA damage response and DNA damage repair pathways. J. Biomed. Optics 18: 095003, 2013.

44. Spitler, R., R. Schwappacher, T. Wu, X. Kong, K. Yokomori, R. B. Pilz, G. R. Boss and M. W. Berns. Nitrosyl-cobinamide (NO-Cbi), a new nitric oxide donor, improves wound healing through cGMP/cGMP-dependent protein kinase. Cell Signal 25: 2374-2382, 2013.

45. Tiwari, N., Chabra, S., Mehdi, S., Sweet, P., Krasieva, T.B., Pool, R., Andrews, B., Peavy, G. M. Imaging of normal and pathologic joint synovium

using nonlinear optical microscopy as a potential diagnostic tool. J. Biomed. Optics 15: 056001 (2010).

46. Wakida, N. M., Botvinick, E. L., Lin, J., Berns, M. W. An intact centrosome is required for the maintenance of polarization during directional cell migration. PLoS ONE 5: e15462. doi:10.13761/journal.pone.0015462 (2010).

47. Wu, T., Mohanty, S., Godinez-Gomez, V., Shi, L., Liaw, L., Miotke, J., Meyer, R. L., Berns M. W. Neuronal growth cones respond to laser-induced axonal damage. J R Soc Interface 9: 535-547 (2012).

48. Xu, X., J. Geng, G. Liu, and Z. Chen, "Evaluation of optical coherence tomography for the measurement of the effects of activators and anticoagulants on the blood coagulation in vitro," IEEE Transaction on Biomedical Engineering 60, 2100 (2013).

49. Yafi A., Vetter, T. S., Pharaon, M. R., Scholz, T., Patel, S., Saager, R. B., Cuccia, D. J., Evans, G. R., Durkin, A. J. Postoperative quantitative assessment of reconstructive tissue status in a cutaneous flap model using spatial frequency domain imaging. Plastic & Reconstructive Surgery 127: 117-130 (2011).

50. Yang, O., and B. Choi. Accelerated rescaling of single Monte Carlo simulation runs with the Graphics Processing Unit (GPU). Biomedical Optics Express, Vol. 4, No. 11, pp. 2667-2672 (2013).

51. Yin, J., Li, X., Jing, J., Li, J., Mukai, D., Mahon, S., Edris, A., Hoang, K., Shung, K. K., Brenner, M., Narula, J., Zhou, Q., Chen, Z. Novel combined miniature optical coherence tomography ultrasound probe for in vivo intravascular imaging. J Biomed Opt 16: 060505 (2011).

52. Yudovsky, D., Durkin, A. J. Hybrid diffusion and two-flux approximation for multi-layered tissue light propagation modeling. Applied Optics 50: 4237-4245 (2011).

53. Yudovsky, D., Durkin, A. J. Spatial frequency domain spectroscopy of two layer media. J Biomed Opt 16: 107005 (2011).

54. Yudovsky, D., J. Q. Nguyen, A. J. Durkin, In Vivo Spatial Frequency Domain Spectroscopy of Two Layer Media, J. Biomed. Optics 17(10), 107006 (Oct 19, 2012). doi:10.1117/1.JBO.17.10.107006

**ABSTRACTS (2010-2013)**

1. Alcaraz Silva, B., and M. W. Berns. Activation of homologous recombination (HR) and non-homologous end joining (NHEJ) repair on double-strand breaks of mitotic telomeres. Am. Soc. Cell Biol. Mtg., Denver, CO, December 3-7, 2011.

2. Alcaraz Silva, B., and M. W. Berns. Live recruitment of double strand break DNA damage signaling and repair factors on mitotic telomeres. Am. Assoc. for the Advancement of Sci. Mtg., Washington, DC, February 17-21, 2011.

3. Berry, J. S., S. M. Belenkiy, R. V. Warren, S. Keene, A. Mazhar, S. B. Mahon, J. Q. Nguyen, O. Yang, B. Yang, M. Brenner, B. Choi, A. J. Durkin, A. Cerrusi, D. J. Cuccia, A. I. Batchinsky, Diffuse Optical Spectroscopy and Spatial Frequency Domain Imaging in a Porcine Model of Exsanguination Induced Cardiac Arrest (ECARP), Military Health System Research Symposium, Fort Lauderdale, FL, Aug. 12-15, 2013.

4. Choi, B., B. Yang, O. Yang, H. Bae, Y.S. Hsiao, C. Crouzet, J. Nguyen, S. Mahon, M. Brenner, A. Durkin, P. Chou, "Camera-based optical imaging of tissue blood flow," Military Health System Research Symposium, Aug. 2013.

5. Choi. B., "Camera-Based Functional Imaging of Tissue Hemodynamics," BiOS Hot Topics, presented at Photonics West Symposium, San Francisco, CA, Feb. 2013.

6. Durkin, A. J., Spatial Frequency Domain Imaging of Skin, Montanga Symposium on the Biology of Skin, Portland, OR, Oct. 11-14, 2013.

7. Ferraro-Gideon, J., Q. Zhu, M. W. Berns and A. Forer. Optical traps can stop movements of Mesostoma spermatocyte kinetochores. Am. Soc. Cell Biol. Mtg., Denver, CO, December 3-7, 2011.

8. Gioux, S., Mazhar, A., Cuccia, D.J., Stockdale, A., Oketokoun, R., Lee, B.T., Ashitate, Y., Durkin, A.J., Tromberg, B.J., Frangioni, J.V. Pre-clinical and clinical validation of a novel oxygenation imaging system. SPIE Photonics West, San Jose, CA (January 22-27, 2011).

9. Gomez Godinez, V., and M. W. Berns. Analysis of the DNA damage response in mitosis. Am. Assoc. for the Advancement of Sci. Mtg., Washington, DC, February 17-21, 2011.

10. Gomez Godinez, V., and M. W. Berns. Analysis of the DNA damage response in mitosis. Am. Assoc. for the Advancement of Sci. Mtg., Vancouver, Canada, February 16-20, 2012.

11. Kaiser, M. Campos, A. Yafi, M. Cinat, A.J. Durkin, B. Choi, "Laser speckle imaging for the assessment of burn wound severity: A prospective clinical study," presented at Advanced Trauma and Combat Casualty Care, Tampa, FL, Aug. 2010.

12. Kim, J.G., Lee, J., Mahon, S.B., Mukai, D.S., Blackledge, W.C., Patterson, S., Boss, G.R., Tromberg, B.J., Brenner, M. Respiratory challenges to detect cyanide toxicity extent in a sublethal rabbit model. SPIE Photonics West 7896-73 (2011).

13. Kim, J.G., Lee, J., Mahon, S.B., Mukai, D., Yoon, D, Brenner, M. Temporary arm occlusion may reveal the level of cyanide toxicity. Am. J. Resp. Crit. Care Med. 183: A5853 (2011).

14. Lee, J., Kim, J.G., Mahon, S., Mukai, D., Yoon, D., Patino, R., Longoria, J., Brenner, M. Diffuse optical spectroscopy monitoring of cytochrome c oxidase redox state during physiological challenges in animal models. Am. J. Resp. Crit. Care Med. 183: A5844 (2011).

15. Lee, J., Kim, J.G., Mahon, S.B., Mukai, D.S., Tromberg, B.J., Brenner, M. Diffuse optical spectroscopy monitoring of cytochrome c oxidase redox state during respiratory challenges in a sublethal rabbit cyanide model. SPIE Photonics West 7896-112 (2011).

16. Liu, G. J., W.C Jia, D. Chou, W.J. Qi, B. Choi, Z.P. Chen, “Intensity-based modified Doppler variance algorithm dedicated for phase instable optical coherence tomography systems,” presented at Photonics West, San Francisco, CA, Jan. 2012 (peer-reviewed paper 821315E).

17. Mazhar, A., Cuccia, D.J., Saggese, S., Nelson, S., Bernal, N., Kaiser, M., Cinat, M., Choi, B., Durkin, A.J. An LED based spatial frequency domain imaging system for clinical applications. Engineering Conferences International, Naples, FL (June 5-10, 2011).

18. Mazhar, A., Sharif, S.A. Saggese, S., Cuccia, D.J., Choi, B., Durkin, A.J. Implementation of an LED based clinical spatial frequency domain imaging system. SPIE Photonics West (January 2012).

19. Mazhar, A., S.A. Sharif, S. Saggesse, D.J. Cuccia, N. Bernal, M. Cinat, M. Kaiser, B. Choi, A.J. Durkin, “A clinical optical imaging system for quantitative wide-field assessment of burn wounds,” presented at Advanced Technology Applications for Combat Casualty Care, Ft. Lauderdale, FL, Aug. 2011.

20. Mazhar, A., T.B. Rice, D.J. Cuccia, B. Choi, A.J. Durkin, D.A. Boas, B.J. Tromberg, “Laser speckle imaging in the spatial frequency domain,” presented at the Optical Society of America Biomedical Optics Topical Meeting, Miami, FL, Apr. 2010.

21. Mittal, R., Balu, M., Liu, G., Chen, Z., Tromberg, B., Wilder-Smith, P., and Potma, E. A minimally-invasive approach to the challenge of oral neoplasia. American Society for Laser Medicine and Surgery (ASLMS) Annual Conference, Boston, MA, 2013.

22. Mittal, R., Balu, M., Liu, G., Chen, Z., Tromberg, B., Wilder-Smith, P., and Potma, E. Development of a coherent Raman scattering fiber probe SPIE, Photonics West, San Francisco, CA, 2013.

23. Mittal, R., Balu, M., Liu, G., Chen, Z., Tromberg, B., Wilder-Smith, P., and Potma, E. Design of a coherent Raman scattering fiber optic probe and its application to biomedical imaging. International

Conference on Raman Spectroscopy (ICORS), Bangalore, India, 2012.

24. Nguyen, J. Q. M.,T. Mai, C. Crouzet, N. Bernal, B. Choi, A.J. Durkin (invited), “Quantitative longitudinal measurement in a rat model of controlled burn severity using spatial frequency domain imaging,” presented at Photonics West Symposium, San Francisco, CA, Feb. 2013.

25. Nguyen, J. Q., C. Crouzet, T. Mai, K. Riola, D. Uchitel, N. Bernal, A. Ponticorvo, L. H. Liaw, B. Choi, A. J. Durkin, Non-invasive assessment of burn wound severities in an acute rat model, Military Health System Research Symposium, Fort Lauderdale, FL, Aug. 12-15, 2013.

26. Nguyen, J.-Q., Saager, R., Cuccia, D., Kelly, K., Hsiang, D., Durkin, A. Motion correction in spatial frequency domain imaging: optical property determination in pigmented lesions. SPIE Photonics West, San Jose, CA (January 22-27, 2011).

27. Pharaon, M.R., Scholz, T., Bogdanoff, S., Cuccia, D., Durkin, A.J., Hoyt, D.B., Evans, G.R.D. Early detection of complete vascular occlusion in a pedicle flap model using quantitative spectral imaging. Am. Soc. Reconstructive Microsurgery Annual Meeting (January 2011).

28. Ponticorvo, A., E. Taydas, A. Mazhar, T. Scholz, H. S. Kim, J. Rimler, G. R. D. Evans, D. J. Cuccia, A. J. Durkin, Early detection of partial vascular occlusions using spatial frequency domain imaging, Military Health System Research Symposium, Fort Lauderdale, FL, Aug. 12-15, 2013.

29. Rice, T. B., E. Kwan, B. Choi, B.J. Tromberg, "Depth Resolved Determination of Particle Dynamics using Laser Speckle Imaging and Spatial Frequency Analysis," presented at Gordon Research Conference on Lasers in Medicine and Biology, Holderness, NH, Jul. 2012.

30. Rice, T. B., S.D. Konecky, A. Mazhar, A.J. Lin, A.J. Durkin, B. Choi, B.J. Tromberg (invited), “Development of coherent Spatial Frequency Domain Imaging (c-SFDI) for simultaneous determination of optical and dynamical properties of tissue,”

presented at Photonics West, San Francisco, CA, Jan. 2012.

31. Saager, R.B., Au, K., Kelly, K.M., Durkin, A.J. Development of spatial frequency domain instrument for the quantification of layer specific optical properties of pigmented lesion. Optical Society of America Conference on Biomedical Optics (April 2012).

32. Saager, R.B., Cuccia, D.J., Durkin, A.J. Method for depth-resolved quantitation of optical properties in layered media using Spatially Modulated Quantitative Spectrosopy (SMoQS). SPIE Photonics West (January 2011).

33. Saager, R.B., D. J. Cuccia, and A. J. Durkin, Spatially Modulated Quantitative Spectroscopy (SMoQS): Determination of optical properties of turbid media spanning visible and near infrared regimes, BO132: Biomedical Applications of Light Scattering IV, Photonics West Jan. 2010.

34. Sheykhani, R., M. W. Berns and A. Forer. Effects of actin and myosin inhibitors on PtK2 spindle length changes induced by laser microbeam irradiations across the spindle. Am. Soc. Cell Biol. Mtg., Denver, CO, December 3-7, 2011.

35. Spitler, R., Schwappacher, R., Wu, T., Pilz, R.B., Boss, G.R., Berns M.W. Nitrosyl-cobinamide promotes wound healing through enhance cell migration. American Society for Cell Biology Annual Meeting (December 2012).

36. Weidling, J., and Botvinick, E. Implantable optical continuous lactate sensor in cyanide poisoning model. Ann. Mtg. of the Biomendical Engineering Soc., Seattle, WA, Sept. 2013.

37. Wu, T., T. A. Nieminen, S. Mohanty, J. Miotke, R. L. Meyer, H. Rubinsztein-Dunlop and M. W. Berns. Directing growth cones of optic axons growing with laser scissors and laser tweezers. Ann. Mtg. of the Soc. of Photo-Optical Instrumentation Engineers (SPIE), San Diego, CA, August 12-15, 2012.

38. Yafi, A., Patel, S., Saager, R.B., Cuccia, D.J., Evans, G.R.D., Durkin, A.J. Postoperative

assessment in a cutaneous flap model using spatial frequency domain imaging. SPIE Photonics West, San Jose, CA (January 22-27, 2011).

39. Yoon, D., Heidari, A., Lee, S.-W., Ramalingam, T., Lee, J., Mahon, S.B., Mukai, D., Chen, Z., Brenner, M. Smoke inhalation induced airway changes quantified using 3D endoscopic optical coherence tomography. SPIE Photonics West 7893-27 (2011).

*40.* Yudovsky, D., and A.J. Durkin, Correction for melanin absorption in a two layer skin model using an artificial neural network in the spatial frequency domain, BiOS, SPIE Photonics West, San Francisco CA, January 2012.

**New discoveries, inventions, or patent disclosures during this reporting period (if none, report none):**

Title: W*ireless continuous glucose monitoring device*
Inventors: E. Botvinick
UC Case: 2013-017-1 (record of invention in process)
Status: Initial evaluation

Title: *Combination of nitric oxide donor (nitrosyl-cobinamide) with low-level light therapy (LLT) for treatment of wounds*
Inventors: M. W.Berns, R. Spitler, G. Boss (UCSD)
UC Case: 2013-772-1
Status: Provisional patent application filed on June 6, 2013 # 61/832,700.

Title: *Method and apparatus for performing qualitative and quantitative analysis of burn extent and severity using spatially structured illumination*
Inventors: A. J. Durkin, A. Mazhar
UC Case: 2012-137-1
Status: Provisional patent application filed on January 25, 2013, # 61,756,988

Title: *Process for analysis of spatially varying signals in media with distinct structures*
Inventors: D. Yudovsky, A. J. Durkin
UC Case: 2012-003-1
Status: Provisional patent application filed on August 11, 2011, #61/523,114. Abandoned UCI Office of Technology Alliances on 6/22/12.

Title: *Rigid endoscopic probe for non-linear optical microscopic imaging*
Inventors: N. Tiwari, G. M. Peavy, E. Potma
UC Case: 2011-624-1
Status: Abandoned by UCI Office of Technology Alliances. No patent prosecution being pursued by the University.

**Patent Granted:**

Title: *Device and method for controlled ablation of microscopic objects using line scissors*
Inventors: J. Stephens, S. Mohanty, M. W. Berns
Status: Patent granted 10/29/13. Number: 8,571,365