SurFACTS in *Biomaterials*

Winter 2018
Volume 23, Issue 1
Twitter @SurfacesIBF

Welcome from President Chris Jenney

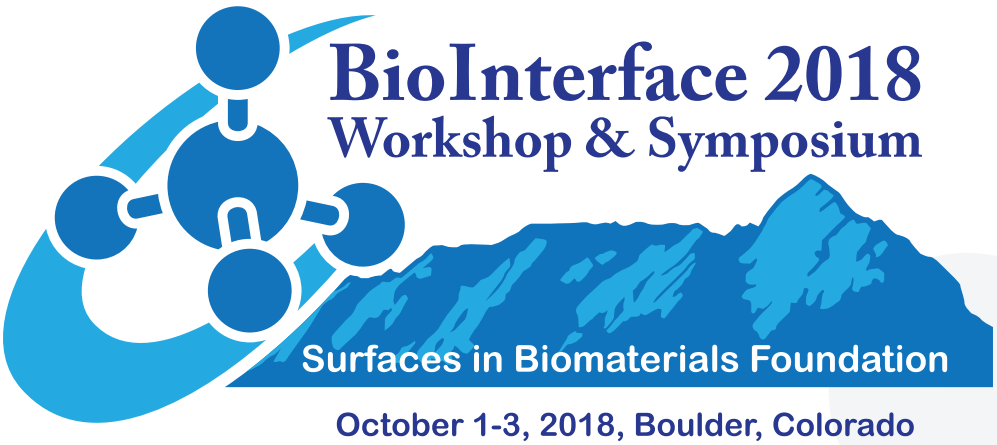
Hello Friends of the Surfaces in Biomaterials Foundation,

Now that we have all returned from the busy holiday break, I wanted to take a moment to reflect on 2017 and look forward to 2018, another exciting year for the foundation. Most importantly, I must thank Bill Theilacker, past president of the foundation, for his leadership throughout 2017. Bill led the board, as well as many generous volunteers and foundation members, through a busy year, culminating in the very successful BioInterfaces 2017 conference. This well-attended event offered a wide range of amazing speakers as well as a beautiful, first-time venue for the Foundation. Moving into 2018 as the new Foundation president, I am joined by a talented group of board members who are very excited about the opportunities in the new year. Please review the bios and images below to get to know the new and returning Foundation board members.

Planning is already underway for the BioInterface 2018 Workshop and Symposium, which will be held Oct. 1 through 3 in Boulder, Colorado. I encourage each of you to visit our website and join our LinkedIn group to obtain the latest information about our upcoming BioInterfaces conference as well as other Foundation activities throughout 2018. Remember that the Foundation relies on strong support from its members and sponsors so that it may continue to serve the scientific and medical device communities. I ask each of you to consider becoming a member, renewing your membership, or becoming a Foundation sponsor in 2018. You can find more information about these opportunities on our website. Please feel free to email me or Bill Theilacker, chairperson of the membership committee, directly for more information.

On behalf of the Surfaces in Biomaterials Foundation, I wish you and your families a prosperous 2018. I look forward to seeing each of you in Boulder!!

Chris Jenney, SIBF president
Chris.jenney@abbott.com



INSIDE THIS ISSUE

October 1-3, 2018, Boulder, Colorado

Workshops/Sessions

MONDAY October 1

BIOINTERFACE WORKSHOP

Theme:
3D Printing in Medical Devices
Co-Chairs: Angela DiCiccio
Verily Life Sciences
Dan Gostovic
Thermo Fischer Scientific

TUESDAY October 2

BIOINTERFACE SYMPOSIUM

Session 1 Topic:
Tissue Engineering and Regenerative Therapies
Co-Chair: Rob Diller
Axolotl Biologix
Roy Biran
W.L. Gore & Associates

Session 2 Topic:
Neurological Devices
Chair: Tim Becker
Northern Arizona University

Session 3 Topic:
Adhesion of Soft Tissues
Chair: Terry Steele
Nanyang Technological University

Session 4:
Point Counterpoint Debate

WEDNESDAY October 3

BIOINTERFACE SYMPOSIUM

Session 5 Topic:
Metallurgy
Co-Chairs: Mallika Kamarajugadda,
Medtronic, plc
Siobhan Carroll, *G. Rau Inc.*

Session 6 Topic:
Metallic Devices
Co-Chairs: Mallika Kamarajugadda,
Medtronic, plc
Siobhan Carroll, *G. Rau Inc.*

Session 7 Topic:
Bioresorable Materials
Chair: Norman Munroe
Florida International University

Session 8 Topic:
Surface Funtionalization and Thin Film Coatings
Co-Chairs: Daniel Higgs
ALD Nano Solutions
Lijun Zou
W.L. Gore & Associates

2018 Call for Abstracts

Abstract Guidelines

ELECTRONIC ABSTRACT SUBMISSION

Authors are encouraged to submit the online submission form by March 4, 2018.

Unlike most Academic symposia, full disclosure of materials, methods, and funding sources is encouraged but NOT required so that presenters may speak about their latest work before it is published in full detail elsewhere.

Accepted abstracts may be revised through March 4, 2018 and will be published on the BioInterface 2018 website that is only accessible to registered attendees. Please submit one form per abstract submission.

Submit only ONE abstract for each presentation; do NOT submit multiple copies of the same abstract, do NOT submit in blinded format, and do include your name, your address and e-mail address on any submitted abstract. Please indicate if you are submitting an oral or poster presentation.

FAILURE TO PRESENT

The presenting author is expected to present the paper. Should an emergency situation occur at the time of your presentation at BioInterface 2018, please notify the Chair of your session as soon as possible. It is the presenting author's obligation to ensure that the abstract is presented.

PRESENTER REGISTRATION

Presenting authors MUST register and pay to attend the event. If registration is not received by August 1, 2018, the presentation will be removed from the program. Online registration will be available on the Surfaces in Biomaterials Foundation website soon.

NOTIFICATION

Notification of acceptance or rejection will be e-mailed in early March. The final selection of abstracts for presentation and placement of accepted abstracts in the program format will be made by the Program Committee.

TITLE

Type the abstract title in upper and lower case letters. Use a concise and descriptive title.

ABSTRACT BODY

The abstract needs to address how the work described relates to the biointerface.

Abstracts accepted for podium presentation will be provided 15 minutes for didactic presentation, followed by 5 minutes for discussion. The nature of the multiple session format makes it imperative that these time limits be strictly observed by all participants. Audio-visual includes a single LCD projector, screen, podium and laptop. Your presentation must not include animation or sublinks to other programs.

All abstracts are due by March 4, 2018. Click here for the online form.

2018 Program Committee

Tim Becker
Northern Arizona University

Roy Biran
W.L. Gore & Associates

Siobhan Carroll
G. Rau Inc.

Chander Chawla
DSM

Joe Chinn,
J Chinn LLC

Angela DiCiccio
Verily Life Sciences

Rob Diller
Axolotl Biologix

Dan Gostovic
Thermo Fischer Scientific

Daniel Higgs
ALD Nano Solutions

Chris Jenney
Abbott

Mallika Kamarjugadda
Medtronic, plc

Courtney Kay
Elkem

Rob Kellar
Development Engineering Sciences, LLC

Renee Klein,
Pace Analytical Life Sciences

Norman Munroe
Florida International University

Archana Rao
BD Medical

Terry Steele
Nanyang Technological University

Bill Theilacker
Medtronic, plc

Lijun Zou
W.L. Gore & Associates

Surfaces in Biomaterials Foundation Board Members

President Chris Jenney, Ph.D.

Chris received his Ph.D. in biomaterials from Case Western Reserve University where his research focused on leukocyte interactions with model surface chemistries. After graduating, Chris joined the research group at St. Jude Medical in Los Angeles. Over his 18 years at SJM/ Abbott, Chris has held technical and management roles in research, quality, and product development. Currently, Chris is a senior principal scientist in charge of materials technology at Abbott with a focus on medical devices designed to treat cardiac arrhythmia and heart failure. Chris and his team focus on identifying new materials and biomaterials technologies that are ready to be rapidly implemented in medical devices.

Vice-President Angela DiCiccio, Ph.D.

Angela DiCiccio is a hardware engineer at Verily Life Sciences working on materials design and synthesis for application in integrated bioelectronic medical devices. Angela earned her Ph.D. in polymer and inorganic chemistry from Cornell University with Professor Geoffrey Coates, where she developed inorganic catalysts capable of copolymerizing biorenewable epoxides and cyclic anhydrides with controlled regio and stereochemistry, affording new classes of polyesters. After her Ph.D., Angela joined Professor Robert Langer and Dr. Giovanni Traverso at MIT to work on the development of new materials for construction of oral drug delivery devices capable of extended-release therapies. Angela's role at Verily cultivates her interests in materials design for challenging applications and enables her to continue working on products with medical applications.

Secretary Archana Rao, Ph.D.

Archana received her Ph.D. in pharmaceutics and pharmaceutical chemistry from the University of Utah in 2012. Her research focused on nucleic acid microarrays, surface analysis and failures in DNA microarrays as a diagnostic tool. She also has a M.S. in chemistry from Bangalore University, India. Archana has fourteen years of industrial experience and has held technical leadership positions at Alcon (Novartis), Bard Access Systems, The Dow Chemical Company and General Electric Plastics. She has expansive technical expertise in medical devices (catheters, glucose sensors), coatings, polymer science, biomaterials, surface analysis and surface modification. Her publications span Analytical Chemistry and Biomaterials journals. Archana works currently at BD Medical as a staff R&D coating engineer developing coatings for PIVCs.

Treasurer Chander Chawla, Ph.D., MBA

Chander is senior director of technology with DSM Biomedical. Chander has worked for DSM for more than 28 years in a variety of roles, including research scientist, R&D manager, technical director, business development, M&A, and strategy and business management. He has master's and Ph.D. degrees in polymer science and an executive MBA from Kellogg School of Management, Northwestern University. Chander has more than 20 U.S. patents and has coauthored more than 40 publications.

President Elect Robert Kellar, Ph.D.

Rob is the founder and president of Development Engineering Sciences, LLC, a biomedical consulting firm. He has more than 15 years of experience in the development and regulatory approval of medical devices, cell-based products, and tissue engineered technology. Previously, Rob was vice president of research and development at Histogen, Inc., where he led multi-functional project teams for all aspects of product development. Prior to Histogen, Rob was a product specialist for the first FDA-approved thoracic endograft at W.L. Gore and Associates, where he served a lead role in development, regulatory, clinical trials, marketing, sales, and business for the thoracic device and the product portfolio. Previous to this position, Rob was a product specialist for the Global Oral Health Business at W.L. Gore & Associates (both Gore-Tex® Regenerative Membranes and the entire resorbable membrane portfolio). Prior to Gore, at Advanced Tissue Sciences, Inc. he led cardiovascular research programs and managed the Anginera® program. Rob previously served on the Scientific Advisory Board for Theregen and

Foundation Board Members ... continues on pg. 5

Foundation Board Members ... continued from pg. 4

the Advisory Board for Flagship Biosciences, a digital pathology company he helped co-found. He currently serves on the Scientific Advisory Board for MyoStim, the Board of Directors for the Surfaces in Biomaterials Foundation, the Advisory Board for Protein Genomics, and the Advisory Board for the California Stock Xchange. Rob's academic laboratory is the Tissue Engineering & Regenerative Medicine (TERM) Lab in the Center for Bioengineering Innovation (CBI) at Northern Arizona University (NAU). He also holds faculty positions in biological sciences and mechanical engineering at NAU. He earned his Ph.D. in physiological sciences from the University of Arizona in the biomedical engineering laboratory of Dr. Stuart K. Williams.

Past President Bill Theilacker, Ph.D.

Bill is a principal scientist at Medtronic Corporate Science and Technology in Minneapolis specializing in the analysis of surfaces, interfaces, and materials to support the development and manufacturing of materials and devices. He is very active externally serving on professional organizations and boards related to surface analysis and spectroscopy: AVS (Biomaterial Interface Division, MN AVS Chapter) and ASTM committee for XPS/Auger standards.

Academic Member Rep. Melissa Reynolds, Ph.D., Colorado State University

Melissa is a Boettcher investigator and associate professor at Colorado State University in the departments of chemistry, biomedical engineering and chemical and biological engineering. She is also currently the research associate dean for the College of Natural Sciences. She received a B. Sc. in chemistry from Washington State University and a Ph.D. from the University of Michigan. Her research focuses on the molecular design and fabrication of biomimetic materials for use in medical device applications, including the development of metal organic frameworks as biocatalysts. She has been recognized as an emerging investigator by the Journal of Materials Chemistry and by the Webb-Waring Biomedical Research Early Career Award, and an NSF CAREER Award. The group's research on metal organic frameworks received a 2013 TechConnect National Innovation Award. Her research has been funded by NSF, NIH, DOD, Boettcher Foundation, state funding and corporate funding. In addition to her academic interests, Melissa is co-founder of Diazamed, a CSU-supported company that works to commercialize research.

Individual Member Rep. Tim Becker, Ph.D.

Tim is a biomedical engineer and associate professor of practice affiliated with the mechanical engineering department and the Center for Bioengineering Innovation at Northern Arizona University. He has more than 20 years of experience in teaching and research in academia, research laboratories, small technology startups, and large industry. Tim enjoys using his experience in academics, research, and industry to provide a well-rounded education to students.

Tim leads the bioengineering devices lab at NAU. His current research interests are in biomedical devices, biomaterials, and vascular blood flow, specifically for treatment of aneurysms in the brain. His current research is toward the optimization of an innovative biomaterial (PPODA-QT) for the endovascular treatment of aneurysms in order to significantly increase therapeutic effectiveness while minimizing surgical risks. Tim is also chief technology officer at Aneuvas Technologies Inc., a startup that is working with NAU to develop PPODA-QT into a new medical device.

Quantitative Analysis and Chemical Mapping Using Confocal Raman Microscopy

Eric Smolensky, Ph. D., Ebatco, 7154 Shady Oak Road, Eden Prairie, MN 55344

Introduction

From pharmaceutical tablets to commercial paints or plastics, it is all but impossible to find products that are not some combination of a multitude of constituents. In addition to the primary component itself, additives are often provided to impart desirable characteristics to final products. In the pharmaceutical industry, excipients (non-active pharmaceutical ingredients) are added to provide bulk to the active pharmaceutical ingredients (API), generate more visually appealing tablets, and help to control the dose release rates as the tablets dissolve. Similarly, common inks often are composed of not only pigments, but also many additives to control their viscosity, adhesion, and solubility properties. While the addition of these additives or excipients is both necessary and desirable, it creates avoidably more complex products, and the resulting content and distribution of the primary and/or active ingredients of these products must be determined by the product manufacturers.

Confocal Raman microscopy has become an invaluable tool to analyze the spatial distribution and chemical composition of materials. With an attainable horizontal spatial resolution of ~250 nm and a vertical spatial resolution of ~500 nm, the WITec 300RA Confocal Raman and Atomic Force Microscope system can obtain high quality chemical maps to aid in the understanding of the distribution of components in a material system. Importantly, the confocal microscope only obtains signal from the focal plane of the microscope; all information from out-of-focus light is rejected from the detector. This helps reduce background noise and allows for the collection of 3D images in optically transparent samples.

Taking the analysis one step further, using the confocal Raman microscopy to determine the relative amounts of API present in pharmaceutical tablets is vital to ensure product quality, accurate labeling, and dosage deliveries. Traditional methods used to calculate relative concentrations of components typically involve time and sample-prep intensive techniques such as HPLC or GCMS. Furthermore, any spatial information or solid structural information is lost due to the destructive nature of HPLC separation. Confocal Raman microscopy, however, is able to overcome many of the limitations presented by traditional methods, and quantitative Raman imaging can address the needs of industries ranging from pharmaceutical API determination to food and beverage ingredient characterization. Finally, the throughput of the analysis using confocal Raman microscopy is so high and sample analysis turnaround so impressively rapid that these Raman systems are already integrated into fast-paced manufacturing processes.

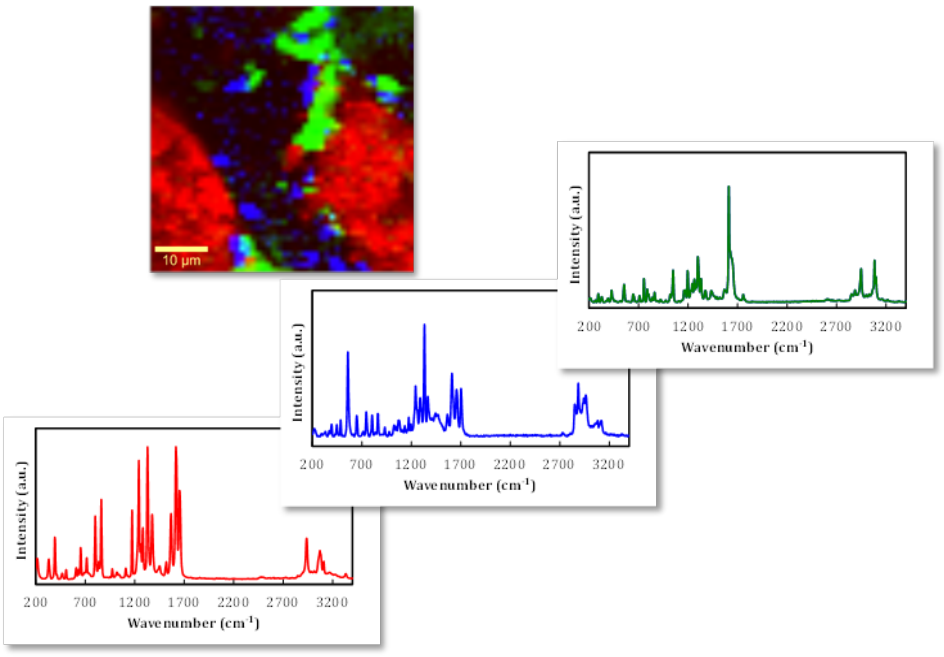


Figure 1. Chemical map of an Equaline® generic tablet and corresponding Raman spectra of the three active ingredients: acetaminophen (red), aspirin (green), and caffeine (blue).

With a submicron laser spot size using a 532 nm laser source, surface area maps can be generated with a lateral resolution of 360 nm in minutes. Chemical images can be generated with a pixel number limited only by the processing power of the computer. Since each pixel in the resulting image map corresponds to a unique spectrum, or mix of spectra, the number of pixels associated with a particular spectrum can be determined. From there, a weighted percent (based on the relative number of pixels) can be calculated for each species of interest. For solid samples, images must be continually obtained until the running average of each component stabilizes. In this communication, the spatial imaging and quantitative analysis capabilities of the confocal Raman microscopy are illustrated through the analysis of a generic brand Equaline® tablet.

2D Spatial Mapping

An Equaline® brand generic tablet was obtained and imaged with scan dimensions of 50 µm × 50 µm at 50 × 50 pixels (2500 spectra, 84 ms/

Quantitative Analysis ...
continues on pg. 7

spectrum) using a 532 nm Nd:Yag laser excitation source. The total acquisition time was 4 minutes. Figure 1 shows the color-coded Raman image obtained by analyzing the distinct spectra corresponding to the three active ingredients: acetaminophen (red), aspirin (green), and caffeine (blue). The black area is excipient (spectrum not shown).

Relative Quantitative Analysis

To determine the relative quantities of each of the APIs (acetaminophen, aspirin, and caffeine) present in the Equaline® pain relief tablet, 15 area maps were generated. Each area map covered an area of 150 µm × 150 µm at 75 pixels × 75 pixels (5625 total pixels each), and the integration time was 74 ms. Each scan took approximately 8 minutes, and the total acquisition time for all 15 scans was 120 minutes. The percentage of each API for each individual area map is shown in Figure 2 (bottom, left) along with the cumulative running average of each API (bottom, right). The relative amounts of acetaminophen, aspirin, and caffeine were determined to be 42 % ± 2 %, 45 % ± 2 %, 11 % ± 1 %, respectively. These values agree well with the Equaline® packaging label, which indicated the relative amount of each API is 44 %, 44 %, 12 %, respectively.

Summary

Determining the relative amounts of API present in a tablet is vital to ensuring product quality and accurate dosage amounts. Naturally, the above process could be repeated for almost any solid that is composed of a variety of constituents. Furthermore, not only can confocal Raman microscopy determine the relative amounts of the individual components of pharmaceutical tablets, copolymers, or food ingredients, but the chemical image also captures the spatial arrangement of each individual ingredient in the product.

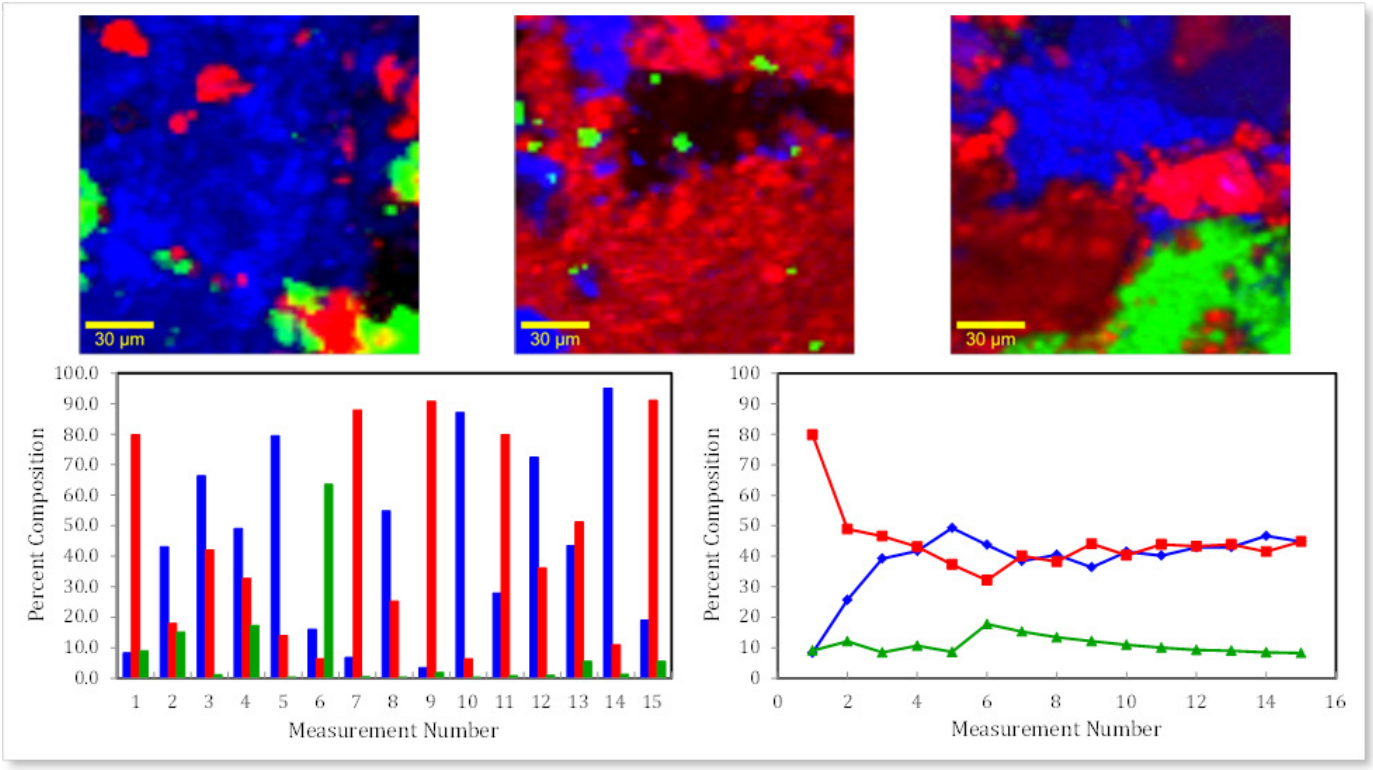


Figure 2. Representative images of an Equaline® pain relief tablet (top). Although each individual area image had varying amounts of API (bottom, left), the running averages of each API stabilized after about 10 to 15 area scans (bottom, right).

Quantification and Correlation of the Adhesion and Durability of Conducting Polymer Films on Metallic Substrates

Jing Qu (BioInterface 2017 Student Poster Award Winner) and David C. Martin
Materials Science and Engineering, University of Delaware, Newark, DE 19716

Organic bioelectronics devices are under development for creating seamless interfaces between living tissue and various engineered components [1, 2]. An important trend is the replacement of hard, inorganic conductors or semiconductors with softer, conducting polymers at the interface between the device and the biological tissue. It has been found that the impedances of conducting polymers at biologically significant frequencies (1-1000 Hz) are substantially lower, and charge storage capacities larger than typical metals and metal oxides including ITO, IrOx, gold, and platinum [3, 4]. This results in superior signal-to-noise ratios, more rapid response times, and lower voltages during stimulation [5]. With the organic composition, and their lower density and stiffness, conducting polymers are also expected to be more chemically and mechanically biocompatible with living tissues [6]. The advantages of conducting polymers such as poly(3,4-ethylene dioxythiophene) (PEDOT) have been demonstrated in cardiac [7] and neural [8] electrotherapies.

However, an important limitation for conducting polymers is their relatively poor mechanical durability. The gradual loss of the conducting polymer from the substrate often observed after extended implantations in-vivo is expected to cause degradation of signal quality, and eventual device failure [9]. It has been observed that PEDOT films often fail via delamination from metallic substrates. It is presumed that delamination resistance in these systems can be improved by increasing interfacial shear strength; unfortunately, interfacial shear strength has proven difficult to quantify with direct measurements.

We are investigating methods to quantify how substrate material and surface modifications affect the interfacial shear strength and durability of PEDOT coatings under electrical and tribological cycling. We have examined a micro-wire loop version of the thin film crack test [10] to characterize the interfacial shear strength of the conducting polymer coating on ductile metallic substrates. The use of an elastically bent single loop has been previously described for evaluating the shear strength and critical deformation strains for brittle films deposited on ductile sheet substrates [11]. We have adapted this method to consider coated cylindrical wires. We have used this method to quantify the interfacial shear strength of PEDOT coatings on the substrates of interest. We found that treating stainless-steel substrates with an adhesion promoter led to a 3.4x increase of interfacial shear strength, from 9.5 MPa to 32 MPa. On untreated gold, the interfacial shear strength of PEDOT was 97 MPa, a value close to the tensile strength of the gold substrate (~100 MPa).

To quantify tribological durability, substrates with thin PEDOT films were slid at small amplitudes and low pressure against pork loin to simulate the chronic physiological interactions between an implanted device and muscle tissue. Combined with a cyclic voltammetry test, we found that an order of magnitude improvement in interfacial shear strength improved the tribological and electrochemical durability of the otherwise unmodified PEDOT films by orders of magnitude. These improvements in interfacial shear strength corresponded to comparable

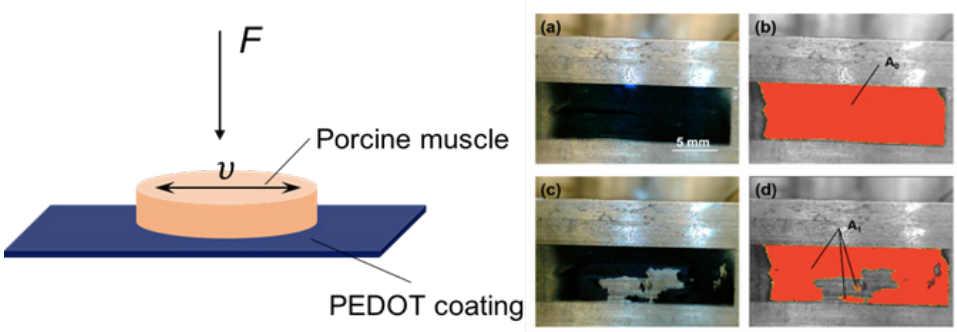


Figure 2. (Left) The setup for the tribological stability test: porcine muscle attached to the loading beam will be rubbed against PEDOT coating deposited on different substrates. (Right) Optical images of PEDOT coating on untreated SS substrate before and during the wear test.

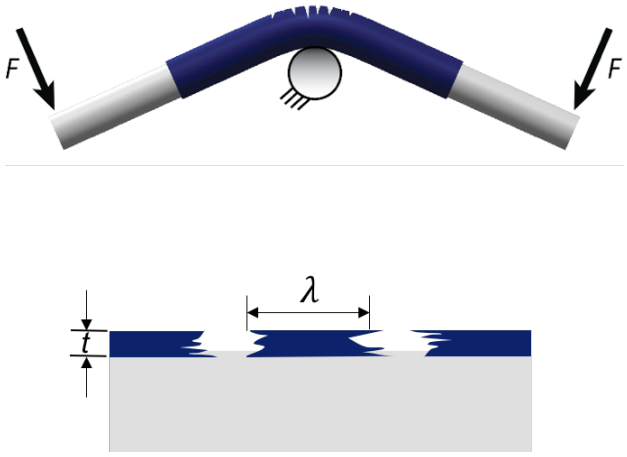


Figure 1. Schematics of the wire bending test. (Top) The PEDOT film forms cracks on top where the strain is the highest. (Bottom) Cross-section of a cracked PEDOT film showing the crack spacing (λ) and film thickness (t).

Quantification and Correlation ...
continues on pg. 10

Surfaces in Biomaterials Foundation

BioInterface Workshop & Symposium

October 2–4, 2017

Catamaran Resort | San Diego, California

Thank you to all who participated in the Biointerface 2017 Workshop and Symposium in San Diego. Also, we wish to recognize the many generous sponsors who made this event possible. The Workshop titled “Trends and Challenges of Medical Device Coating Technologies,” co-chaired by Bill Theilacker and Chris Jenney, highlighted focus areas in hydrophilic, antimicrobial, thromboresistant and drug delivery coatings. The Applied Technology session addressed the challenges of catheter development and characterization of surfaces and leachables. The Symposium featured a Keynote lecture by Buddy Ratner followed by a social mixer at the Pacific Beach Ale House. The remaining two days of the Symposium featured presentations from both industry and academic attendees on a wide range of topics, including implantable medical devices, sensors for space, and structure-function relationships for biomaterials, to name just a few. The closing day featured the Point-Counterpoint session, a debate of the controversial topic “Implantable biomaterial development is dead,” between Professors Buddy Ratner and Stuart Williams. Congratulations to our student poster winter Jing Qu (advisor David Martin) from the University of Delaware and our Excellence in Surface Science award winner Victoria E. Carr-Brendel from JenaValve Technology, Inc. We look forward to seeing everyone this year in Boulder, Colorado on Oct. 1!

Thank you, 2017 Sponsors and Exhibitors!

Gold Sponsors:

Abbott

Medtronic

DSM

GORE Creative Technologies Worldwide

Exhibitors:

Axolotl Biologix
BioInteractions
BioNavis
Carmeda
CBSET
EAG Laboratories
Ebatco
Euroflex
JPK Instruments AG
Pace Analytical
Physical Electronics
Sono-Tek Corporation
Surface Solutions Labs, Inc.
Tascon GmbH
Thermo Fisher Scientific
University of Utah Nanofab

Session sponsors: Elkem Silicones and EAG Laboratories

Quantification and Correlation ... continued from pg. 8

improvements in resistance to mechanical degradation under electrochemical and tribological stresses.

Our research has demonstrated that with appropriate selection of the substrate and use of appropriate chemistries and processing methods, considerable improvements in coating adhesion and durability can be obtained. These improvements correlate strongly with the interfacial shear strength, which can be quantified with the wire loop test.

The details of this work have been submitted for consideration for publication to ACS Applied Materials & Interfaces on Nov. 10, 2017.

References

1. *Forrest, S. R. The path to ubiquitous and low-cost organic electronic appliances on plastic. Nature 428, 911–918 (2004).*
2. *Berggren, M. & Richter-Dahlfors, A. Organic bioelectronics. Adv. Mater. 19, 3201–3213 (2007).*
3. *Wilks, S. J., Richardson-Burns, S. M., Hendricks, J. L., Martin, D. C. & Otto, K. J. Poly(3,4-ethylenedioxythiophene) as a Micro-Neural Interface Material for Electrostimulation. Front. Neuroeng. 2, 7 (2009).*
4. *Boehler, C., Oberueber, F., Schlabach, S., Stieglitz, T. & Asplund, M. Long-term stable adhesion for conducting polymers in biomedical applications: IrOx and nanostructured platinum solve the chronic challenge. ACS Appl. Mater. Interfaces 9, 189–197 (2016).*
5. *Sessolo, M. et al. Easy-to-Fabricate Conducting Polymer Microelectrode Arrays. Adv. Mater. 2135–2139 (2013). doi:10.1002/adma.201204322*
6. *Lind, G., Linsmeier, C. E. & Schouenborg, J. The density difference between tissue and neural probes is a key factor for glial scarring. Sci. Rep. 3, 2942 (2013).*
7. *Xu, L. et al. Materials and fractal designs for 3D multifunctional integumentary membranes with capabilities in cardiac electrotherapy. Adv. Mater. 27, 1731–1737 (2015).*
8. *Kung, T. et al. Regenerative peripheral nerve interface viability and signal transduction with an implanted electrode. Plast. Reconstr. Surg. 133, 1380–94 (2014).*
9. *Kozai, T. D. Y. et al. Mechanical failure modes of chronically implanted planar silicon-based neural probes for laminar recording. Biomaterials 37, 25–39 (2015).*
10. *Qu, J., Ouyang, L., Kuo, C. C. & Martin, D. C. Stiffness, strength and adhesion characterization of electrochemically deposited conjugated polymer films. Acta Biomater. 31, 114–121 (2016).*
11. *Martin, D. C. Elastica bend testing of the effective interfacial shear strength and critical deformation strains of brittle coatings on ductile substrates. Prog. Org. Coatings 48, 332–336 (2003).*

Surfaces in *Biomaterials* Foundation

SurFACTS in Biomaterials is the official publication of the Foundation and is dedicated to serving industrial engineers, research scientists, and academicians working in the field of biomaterials, biomedical devices, or diagnostic research.

Thank You to Our Members!

APS
AMERICAN PRECLINICAL SERVICES

ExThera Medical

AST
PRODUCTS, INC.

BioCoat
INCORPORATED

BioInteractions
Advancing Healthcare Through Innovation™

Northern Arizona University

RICE
Unconventional Wisdom

carmeda
A SUBSIDIARY OF W. L. GORE & ASSOCIATES

PHYSICAL ELECTRONICS
A DIVISION OF ULVAC-PHI

verily

Space Foundry
Print with Molecular Precision

Abbott

Colorado State University

Surface Solutions Laboratories™

GORE
Creative Technologies Worldwide

DSM

ASPEN RESEARCH

BAUSCH + LOMB

ibi INTERFACE biologics
A Material Advantage

Boston Scientific

SurModics

Medtronic

CBSET

EAG LABORATORIES | WE KNOW HOW™

Pace Analytical®