**NCCAVS
Plasma Applications GROUP
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**Topic:  Medical Applications of Plasma Processing**

**Meeting Date:  November 17, 2014**

**Start Time:  2:00 – 5:00pm**

**Location:** SEMI Global Headquarters
    Seminar rooms 1 & 2
    3081 Zanker Road
    San Jose, CA 95134
   \*\***Park in front or behind the
   vacant building across from SEMI\*\***

**Chairs:** David J. Coumou, MKS Instruments, Inc., David\_Coumou@mksinst.com

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**AGENDA**

**2:00 - 2:35 “A Market Landscape of the BioMedical Plasma Application Field”**, Robert Castellano, Frost and Sullivan

**2:35 - 3:10 “Non-Thermal Plasmas for Biomedicine: A New Frontier in Plasma Processing”**, David B Graves, University of California Berkeley, Department of Chemical Engineering

Thirty years ago, low temperature, low-pressure, non-thermal glow discharge plasmas were being explored for the rapidly growing semiconductor industry and related thin film technologies. Challenges in thin film device plasma processing continue to this day due to the remarkable evolution of semiconductor devices associated with nano-scale features, many new materials, new lithographic approaches, introduction of larger wafers and so forth.

A new field of non-thermal plasma processing associated with biomedicine has emerged that is reminiscent of the earlier transformation in thin film materials plasma processing. In this new field, plasmas are used to interact directly and therapeutically with living tissue. [1] Researchers throughout the world have shown that atmospheric pressure, near-room temperature plasmas can be used to shrink tumors, promote wound healing and sterilization, and treat dermatological and dental disease, among other things. As before, the inherent complexities and coupled, often synergistic mechanisms associated with plasmas are being investigated. In this new field, however, using plasma to alter complex biological ‘targets’ make the challenges even greater.

In this talk, I will highlight some of the recent advances in the rapidly changing field of plasma biomedicine and focus on the role of reactive oxygen species (ROS) and reactive nitrogen species (RNS). ROS and RNS (or RONS), in addition to a suite of other radical and non-radical reactive species, are essential actors in an important sub-field of aerobic biology termed ‘redox’ (or oxidation-reduction) biology. I will review the evidence suggesting that RONS generated by plasmas are responsible for their observed therapeutic effects.[2]

References:

[1] M.G. Kong, et al., *New Journal of Physics*, **11**, article no. 115012, 2009.

[2] D.B. Graves, *Journal of Physics D-Applied Physics*, **45**(26), article no. 263001, 2012.

**3:10 - 3:25 Break**

**3:25 - 4:00 “Investigating the Interface Between Plasmas and Aqueous Solutions"**, Alex Lindsay, North Carolina State University, Department of Nuclear Engineering

Interaction of atmospheric plasmas with liquids is a rich scientific and engineering field with potential applications in biomedicine, waste degradation and disinfection, sustainable agriculture, etc. However, in order to realize the full potential of these applications, the transport and reactions of charged species, neutrals, and photons at the interface between plasmas and liquids must be better quantified and understood. The work presented here combines mostly theoretical with some experimental investigations of conditions in the gas and liquid phases in proximity to the interface for a pulsed streamer discharge. The influence of the ionic wind on reactive species dissolution is presented. The coupled heat and mass transfer problem arising from convective evaporation of water and the potential role this plays on aqueous phase kinetics is also considered. Because of the highly reactive nature of certain plasma generated species such as OH, it is shown that a highly reactive layer of 1-10 microns occurs at the interface. This result is pertinent for applications in which plasma reactivity needs to be conveyed through the interface and into the bulk solution or to an underlying substrate. Model results investigating formation of charged specie double layers at the interface and near the immersed ground electrode may also be presented. Experimentally, the effects of surface vs. bulk solution reactivity are examined through comparing reaction of an indigo dye with both plasma activated water and a representative synthetic solution containing hydrogen peroxide, nitrite, and nitrate. Finally, results of applying plasma activated water to radishes, tomatoes, and marigolds in a controlled greenhouse environment are shown.

**4:00 - 4.35 “In-vitro Fungal Eradication by Atmospheric Pressure Plasma”**, Jeffrey Roe, DeviceFarm, Inc.

Onychomycosis is a common fungal infection of the nail with significant barriers to successful treatment [1]. The prevalence of onychomycosis is estimated to affect 10% of the world's adult population [2], particularly the elderly and patients with immunodeficiency diseases such as HIV, diabetes and circulatory disorders. Contributing to treatment difficulty is the challenge of getting topical antifungal agents through the nail. Systemic oral medications have a higher cure rate, but the oral drug pathway poses liver toxicity risks. There is an unmet medical need for a topical cure that eliminates this chronic infection effectively.

Nonthermal plasma in air generates antimicrobial reactive oxygen and nitrogen species that are capable of efficiently destroying fungal cells. Nitrites, H2O2 and ozone have been detected in our plasma stream. Acidified nitrite has been reported to kill nail fungus by forming S-nitrosothiols in the nail [3], suggesting air plasma may be a promising way to create and deliver a therapeutic antifungal compound to the infected nail.

This talk will highlight recent experimental results showing the inactivation of T. rubrum fungal colonies with both He/O2 plasma jet and air surface microdischarge (SMD) plasma-generated species. The treatment protocol includes diffusion of reactive species through a bovine hoof disk. Bovine hoof is an established in vitro nail model for antifungal drug testing.

References:

[1] E. Epstein, Arch Dermatol, 134:1551, 1998.

[2] M.A. Repka, J. O'Haver, C.H. See, et al., Int J Pharm, 245:25, 2002.

[3] M.J. Finnen, A. Hennessy, S. McLean, Y. Bisset, R. Mitchell, I.L. Megson and R. Weller, British Journal of Dermatology, 157, 494, 2007.

All presentations will be requested to be posted on the PAG Proceedings webpage.

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