Conformal Atmospheric Pressure Plasmas for Biomedical Applications: Along Surfaces, Inside Tubes and Penetrating Cracks

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The direct use of atmospheric pressure plasmas (APPs), such as dielectric barrier discharges (DBDs) and ionization waves (IWs), in biomedical applications rely on delivery of active species to non-planar surfaces and remote locations. In the treatment of human tissue, the surface is rarely flat and may have convex, concave or sloping topography. In plasma sterilization of surfaces or delivery of plasma to remote locations, surfaces range from branched tubes and channels, to deep cracks as might be encountered in deactivating bacteria or viruses on industrial contaminated surfaces. The common feature of these APPs is the ability, or need, for the plasma to propagate in a conformal manner along the surface. In this paper, results from computational and experimental investigations of conformal propagation of APPs for biomedical applications will be discussed. The computations were performed using a 2-dimensional plasma hydrodynamic model.[1] The experiments provide ns resolved images of the conformal propagation of APPs.[2]

We found that pulsed APPs in the form of IWs, as might be launched in DBDs, conformally propagate along surfaces in a manner determined by the capacitive charging of those surfaces. Propagation is slowed in regions of high capacitance and speeds up in regions of low capacitance. As gas phase streamers charge surfaces, components of the electric field are produced parallel to the surface which directs the now surface wave to uncharged regions. Model results and imaging of the propagation of surface hugging IWs in branched tubes are explained by the reliance on surface charging to split IWs and turn corners. This also contributes to DBD filaments which strike sloped surfaces, such as human tissue, being able to fairly uniformly treat the surface. (See Fig. 1.) The IW propagating along the surface is directed by electric fields oriented towards uncharged regions. Results will also be discussed for plasma propagation into high-aspect-ratio features such as cracks.

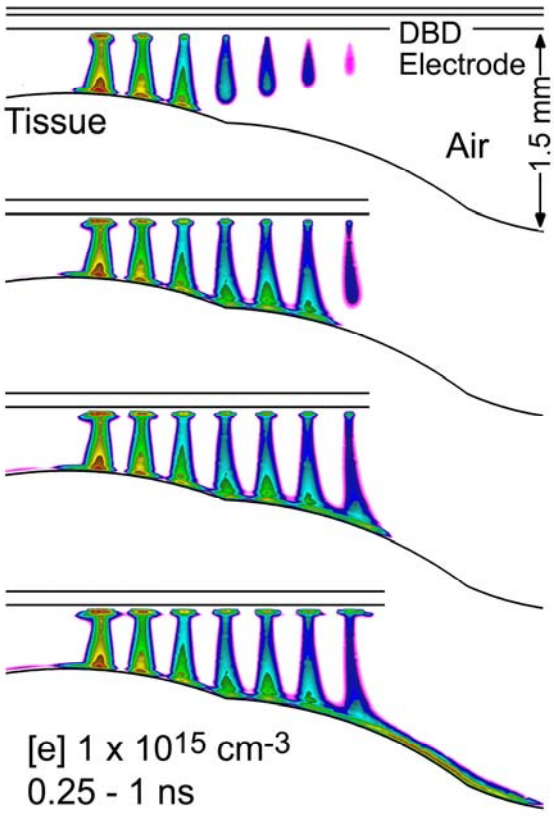

Figure 1: *Electron density for simultaneously launched DBD filaments in air striking human tissue, and conformally propagating along the surface.*

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References

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