Prof. Michael Keidar

George Washington University

Physics and Medical Applications of Cold Atmospheric Plasmas

Intense research efforts in low-temperature (or cold) atmospheric plasma (CAP) applications in bioengineering led to the foundation of a new field, plasma medicine. CAPs have the ability to perform minimally-invasive surgery that allows specific cell removal without influencing the whole tissue. Varieties of novel plasma diagnostic techniques were applied in a quest to understand physics of cold plasmas. In particular it was established that the streamer head charge is about 10^8 electrons, the electrical field in the head vicinity is about 10^7 V/m, and the electron density of the plasma column is about $10^{19}m^{-3}$. We have demonstrated the efficacy of CAP in a pre-clinical model of various cancer types (lung, bladder, breast, head, neck, brain and skin). Both in-vitro and in-vivo studies revealed that CAPs selectively kill cancer cells. We showed that: (a) CAP selectively eradicates cancer cells in vitro without damaging normal cells and (b) significantly reduced tumor size in vivo. CAP treatment led to tumor ablation with neighboring tumors unaffected. We found that tumors 5 mm in diameter were ablated after a single 2 min plasma treatment. The two best known CAP effects, plasma-induced apoptosis and the decrease of cell migration velocity can have important implications in cancer treatment by localizing the affected area of the tissue and by decreasing metastasic development. CAP affected the cell cycle of cancer cells by inducing a 2-fold increase in cells at the G2/M-checkpoint in both papilloma and carcinoma cells at ~24 hours after treatment, while normal epithelial cells did not show significant differences. It was shown that reactive oxygen species (ROS) metabolism and oxidative stress responsive genes are deregulated. We investigated the production of ROS with CAP treatment as a potential mechanism for the tumor ablation observed.

About the Speaker: Michael Keidar is a Professor of Mechanical & Aerospace Engineering, and Neurological Surgery at the George Washington University. He received the M.Sc. degree with honors from Kharkov Aviation Institute in 1989 and the Ph.D. degree from Tel Aviv University in 1997. He was a Fulbright Fellow with Lawrence Berkeley National Laboratory, a Research Associate with Cornell Univ., and a Research Scientist and Adjunct Professor with the Univ. of Michigan. His research is advanced spacecraft propulsion, plasma-based nanotechnology, plasma-material interactions, and plasma medicine. He has authored >150 journal articles and the textbook “Plasma Engineering: Applications from Aerospace to Bio and Nanotechnology” (Elsevier, 2013). Prof. Keidar is Guest Editor of the IEEE TRANS PLASMA SCIENCE, Editor-in-chief of Graphene, member of Editorial Board of Scientific Reports (Nature) and Director of GW Institute for Nanotechnology. He is Fellow of APS, Associate Fellow of AIAA, and General Chair of the 33rd IntL. Electric Propulsion Conference.