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High power impulse magnetron sputtering (HIPIMS) and traditional pulsed sputtering (DCMSP) Ag-surfaces leading to *E. coli* inactivation

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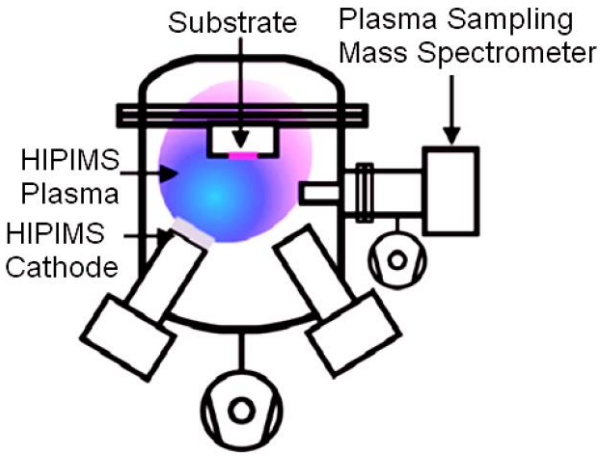
This study addresses the high power impulse magnetron sputtering (HIPIMS) deposition of Ag-nanoparticle films on polyester and the comparison with films deposited by direct current pulsed magnetron sputtering (DCMSP).



Schematic of the HIPIMS setup, the cathode used was Ag and the substrate polyester

The first evidence is presented for the *E. coli* bacterial inactivation by HIPIMS sputtered polyester compared to Ag-polyester sputtered by DCMSP. HIPIMS layers were significantly thinner than the DCMSP sputtered layers needing a much lower Ag-loading to inactivate *E. coli* within the same time scale. The Ag-nanoparticle films sputtered by DCMSP at 300 mA for 160s was observed to inactivate completely *E. coli* within 2 hours having a content of 0.205% Ag wt%/polyester wt%. HIPIMS-sputtered at 5 Amp for 75s led to complete *E. coli* bacterial inactivation also within 2 hours having a content Ag 0.031% Ag wt%/polyester wt%. The atomic rate of deposition with DCMSP is 6.2×10^{15} atoms Ag/cm^{2}s while with HPIMS this rate was 2.7×10^{15} atoms Ag/cm^{2}s. The degree of ionization of Ag^+/Ag^{2+} and Ar^+/Ar^{2+} was proportional to the target current applied during HIPIMS-sputtering as determined by mass spectroscopy. These experiments reveal significant differences at the higher end of the currents applied during HIPIMS sputtering as illustrated by the ion-flux composition. X-ray photoelectron spectroscopy (XPS) was used to determine the surface atomic concentration of O, Ag, and C on the Ag-polyester. These surface atomic concentrations were followed during the *E. coli* inactivation time providing the evidence for the *E. coli* oxidation on the Ag-polyester. X-ray diffraction shows Ag-metallic character for DCMSP sputtered samples for longer times compared to the Ag-clusters sputtered by HIPIMS leading to Ag-clusters aggregates. Ag-nanoparticle films on polyester sputtered by HIPIMS contain less Ag and are thinner compared to Ag-nanoparticle films sputtered by DCMSP.

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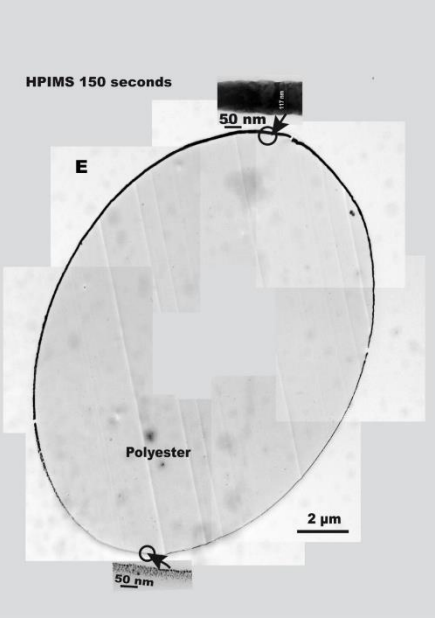
The mass spectroscopy analysis of the ions in the chamber was carried out by way of a Hiden mass spectrometer connected with the DC-magnetron gas chamber. The Ar^+, Ar^{2+} and Ag^+ and Ag^{2+} ions were determined. With increasing current the Ar^+ decreases and the Ag^+ gas phase increases. At higher discharge currents Ag^+-ions exceeded the amount of Ar^+-ions. The most interesting result is that HIPIMS discharges at 10 A peak current produced high quantities of Ag^+-ions along a small amount of Ag^{2+}-ions.



Transmission electron microscopy of Ag-polyester fibers sputtered by HIPIMS at 5 Amps for 150s. E in stands for epoxide used during the preparation

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