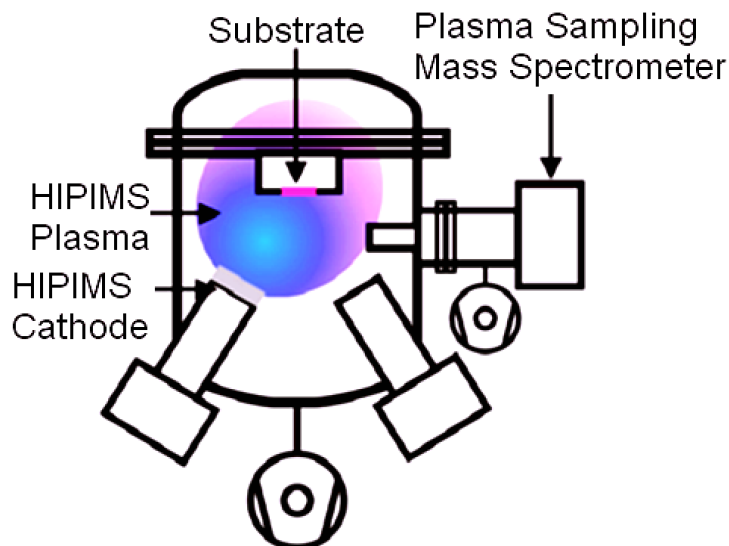


Advantages of highly ionized pulse plasma magnetron sputtering (HIPIMS) of silver for improved *E. coli* inactivation

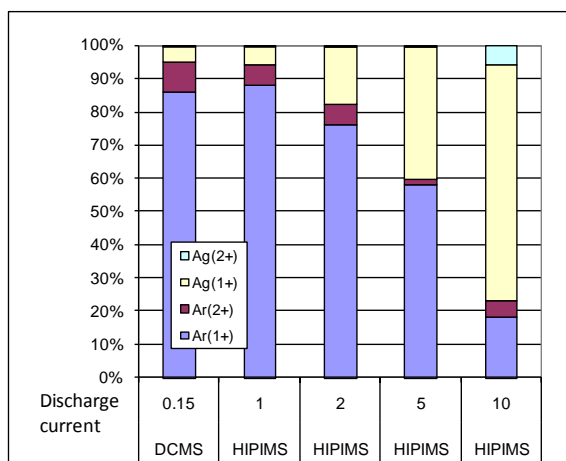
This study addresses the DC-magnetron sputtering (DCMS) of Ag-films on polyester and compares the results found for the *E. coli* inactivation with the inactivation obtained when applying highly ionized pulse plasma power magnetron sputtering (HIPIMS).



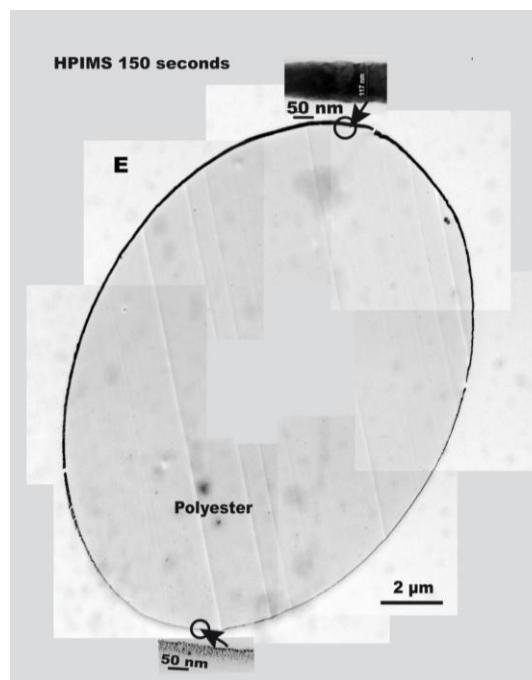
Schematic of the HIPIMS setup, the cathode used was Ag and the substrate polyester

The amounts of Ag needed to inactivate *E. coli* by HIPIMS sputtering were an order of magnitude lower than with DCMS indicating a significant saving of noble metal and concomitantly a faster *E. coli* inactivation was observed compared to samples sputtered with DCMS. Higher current densities applied with DCMS led to shorter *E. coli* inactivation times and this trend was observed also for HIPIMS sputtered samples. By DCMS the thicker layers needed to inactivate *E. coli* comprised slightly larger Ag-aggregates compared to the thinner Ag-layers sputtered by HIPIMS to inactivate *E. coli* within short times. Longer sputtering times by DCMS and HIPIMS lead to optically darker Ag-deposits reaching the absorption edge of silver absorption of ~1000 nm. Mass spectroscopic analyses indicated that HIPIMS produced a much higher amount of Ag¹⁺ and Ag²⁺ compared to DCMS due to the higher peak discharge current employed in the former case.

Plasma ion-composition analysis of HIPIMS and DCMS sputtering in Argon, derived from mass spectroscopy analysis. HIPIMS is applied at the currents indicated in the Figure.



TEM of an Ag-polyester fiber sputtered by DCMS for a) 160 s at 300 mA at 5 A for 150 s and b) HIPIMS at 5 A for 150 s.



The mass spectroscopy analysis of the ions in the chamber was carried out by way of a Hidden 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.

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