Surface Cleaning with Atmospheric Pressure Plasma Jets investigated by Optical Emission Spectroscopy and LIBS

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Atmospheric pressure plasma jets (APPJs) are increasingly employed for industrial applications such as surface cleaning, modification of surfaces, deposition of coatings and for bio-medical applications such as skin treatment and bacterial inactivation [1]. In this research, the plasma of an industrial APPJ (Acerios, Fronius International GmbH) is investigated and applied to the cleaning of surfaces [2]. The device operates a spark discharge in Argon gas flow in the few kW power range resulting in a continuous and powerful plasma jet expanding into ambient air. The APPJ plasma parameters are measured by Optical emission spectroscopy (OES) and the plasma cleaning of coated sample surfaces is monitored by OES and Laser-induced breakdown spectroscopy (LIBS). For the characterization of plasma by OES a new methodology is developed [3]. The plasma electron temperature T_e and electron number density N_e are determined accurately by evaluating the Ar (I) and Ar (II) emission lines using the Saha-Boltzmann plot method. For the cleaning experiments samples are coated with organic oil layers of 0.5 to 10 µm thickness. The APPJ plasma cleaning efficiency is calculated from measured spectra and the atomic lines and molecular bands of species originating from the contamination layer. Chemical imaging of samples before and after plasma cleaning is performed by LIBS. Spatial profiles of the cleaning efficiency are measured. We find a strong influence of the APPJ plasma parameters and the type and thickness of contamination layer on the efficiency of the cleaning process. For instance, the cleaning becomes more efficient at higher power of the plasma generator (CN violet band emission measured in situ by OES).

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References

[1] C. Tendero, C. Tixier, P. Tristant, J. Desmaison, P. Leprince. Atmospheric pressure plasmas: A review. Spectrochimica Acta Part B: Atomic Spectroscopy, 61, pp. 2–30 (2006).

[2] Y. Jin, C.-S. Ren, L. Yang, D. Wang. Comparative Study of the Surface Cleaning for Ar-/He-Based Plasma Jets at Atmospheric Pressure. IEEE Transactions on Plasma Science, 43, pp. 3193–3199 (2015).

[3] N. Giannakaris, G. Gürtler, T. Stehrer, M. Mair, J.D. Pedarnig. Optical Emission Spectroscopy of an industrial thermal Atmospheric Pressure Plasma Jet: Parametric Study of Electron Temperature, (under review).