The Use of Optical Emission Spectroscopy for Inline Monitoring of the Atmospheric Pressure Plasma Pre-treatment Process in Adhesive Bonding Technology

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1. Introduction and motivation

An appropriate state of adherend surfaces is essential for stability and reliability of an adhesive bond. Therefore, an effective surface cleaning and/or activation are a key issue for the adhesive bonding technology. Atmospheric pressure plasma jets are often used for pre-treatment in industry, due to their high compatibility with existing process chains. However, efficiency of the pre-treatment regarding the quality of the adhesive bond can often be evaluated only by destructive mechanical tests. Therefore, methods to analyse the surface state and the plasma processing before the bonding are sought for a quality assured pre-treatment.

Laser Induced Breakdown Spectroscopy (LIBS) is a type of optical emission spectroscopy (OES) which enables detection and semi-quantitative analysis of characteristic contamination species on the sample surface excited by means of a laser. In particular, intensity ratios of the detected emission lines measured before and after the plasma processing can provide information on efficiency of the pre-treatment process. In the present work, a similar approach was developed, whereas the plasma jet applied for the surface pre-treatment was simultaneously used as an excitation source for an oil-like contamination on the treated substrates. Thus, plasma pre-treatment and process control were combined. The LIBS technique was also employed in this study as a reference method.

2. Experimental part

Aluminium substrates contaminated with a lubricant commonly used for the sheet metal forming were chosen as a model system in the following studies. Defined amounts of the lubricant were sprayed on the substrates resulting in various contamination concentrations up to 5 g/m^2. An atmospheric pressure plasma jet operated with compressed air was applied for the surface treatment of the substrates, whereas the plasma jet served simultaneously as an excitation source for the lubricant components measured by OES. Emission of the excited species was collimated, focused into an optical fiber and analysed in the spectral range from 200 nm to 800 nm using two spectrometers of different spectral resolution.

3. Results

Sodium and calcium were found to be characteristic elements in the selected contamination. These elements are well detectable during the plasma treatment by means of OES (Fig. 1). Aluminium emission lines from the substrate were used as reference signal. Ratios of the peak areas from calcium and aluminium could be assigned to different amounts of the lubricant on the substrates (Fig. 2). This provided a tool to analyse the surface state of the treated samples and thus monitor the efficiency of the plasma treatment during the process. Finally, the obtained results were verified by LIBS measurements.

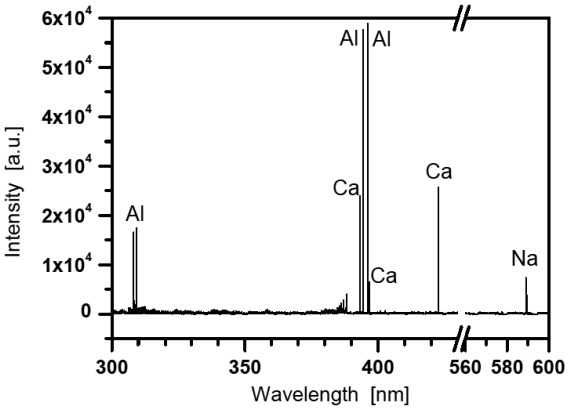

Fig. 1: *Typical emission spectra measured during the plasma treatment of contaminated Al-substrate.*

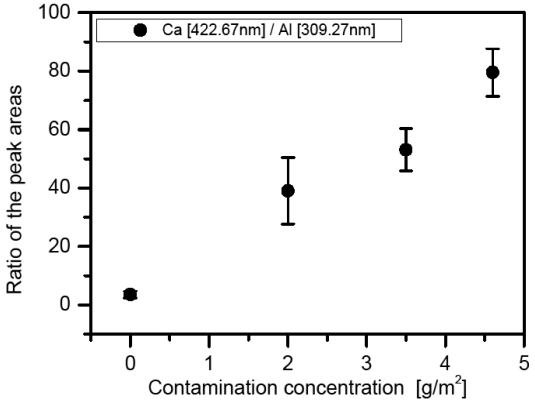

Fig. 2: *Ratios of the peak areas from Ca and Al for different amounts of lubricant on the plasma treated Al-substrates.*