Effect of aluminum alloys’ surface roughness on galvanic layers adhesion

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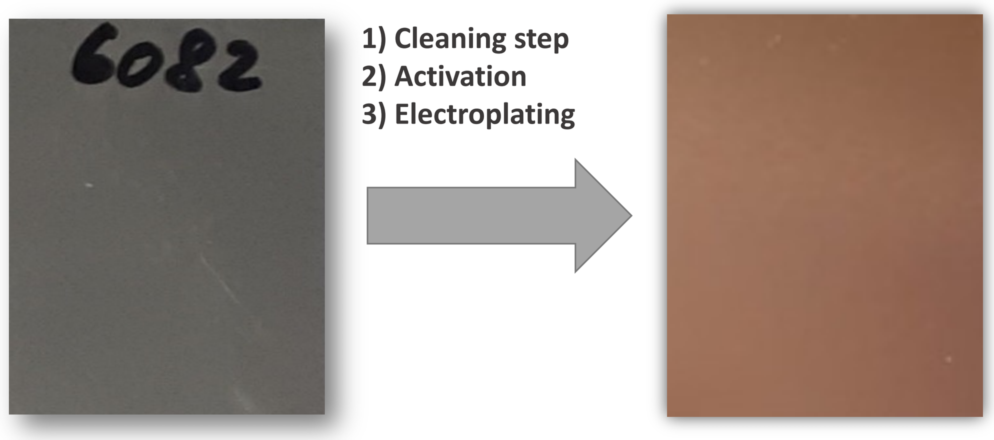
Introduction

Within the fashion-jewelry sector, the major fashion houses are constantly pursuing new viable ways to render more sustainable their whole value chain. First of all, these players are looking at making use of green and eco-compatible base materials still keeping economically feasible processes. Concerning fashion items and accessories like chains, rings, earrings, bracelets and so on, among a wide variety of suitable base materials, aluminum is one of the most interesting because is unlimitedly recyclable and is spread throughout the world, hence is largely available and cheap. However, aluminum is not that easy to be galvanized, especially when it comes down to the so-called “secondary aluminum”, which is the aluminum that comes from the recycling process. Indeed, besides quickly and spontaneously forming a 20 nm thick layer of aluminum oxide when exposed to the air [1] (also primary aluminum undergoes this natural process), secondary aluminum might contains a broad range of metallic impurities that hinder the electroplating process, leading to weak adhesions between galvanic layers being deposited. Since most of the available aluminum on the market is recycled, it has been catalogued depending on the type of impurities that it contains. Methods for cleaning and properly activating its surface have been developed through the years and turned out to be different depending on the type of aluminum to be treated [2,3]. However, so far, a study focussing on determining the impact of the aluminum surface roughness on the quality of the adhesion between the base material and the first galvanic layer has not yet been done.

Materials and Method

Al6082 was used as base material. This type of aluminum belongs to the ANTICORODAL series, widespread and easily available on the market due to its great corrosion resistance. Samples with dimension 50x38x1 (mm) were cut out of a big aluminum foil: some of them were mechanically polished in order to reduce their surface roughness whereas others were left as they were. Roughness measurements were performed by means an HOMMEL WAVE profilometer as well as with AFM. Samples pre-treatment, chemical activation and electroplating were performed within VALMET PLATING Srl, making use of proprietary galvanic bath formulations.
SEM-EDS (Hitachi SU3800) analysis were eventually carried out to gather data concerning the composition of the electrodeposited layers, their adhesion as well as to take pictures of the surface of the samples. Adhesion between layers was also assessed according to the UNI EN ISO 2819: 2018 standard criterion.

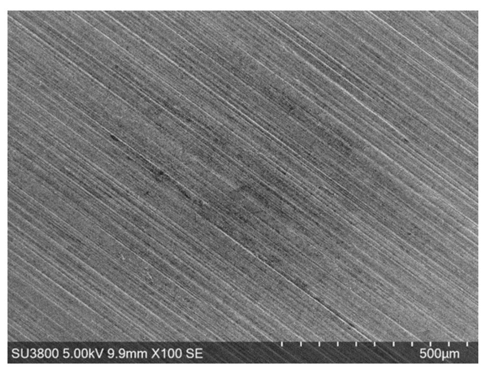
SEM ANALYSIS	
Element	% m/m
Al	97.3
Mg	1.0
Si	0.8
Mn	0.6
Fe	0.3



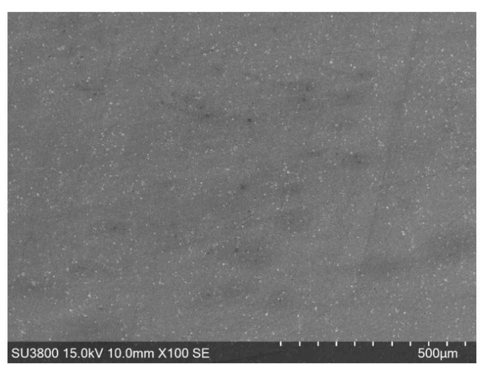
Experimental results

To evaluate the impact of the base material surface roughness on the resulting adhesion between aluminum’s surface and the first galvanic layer being deposited, two samples cut out of an aluminum 6082 foil were galvanized according to a well known procedure easily available in literature [4]. One, out of these two samples, was previously polished in order to obtain a low surface roughness, as pointed out in the following tables, where averages are calculated by means of 5 measurements for each sample. AFM analysis were carried out in “contact mode”.

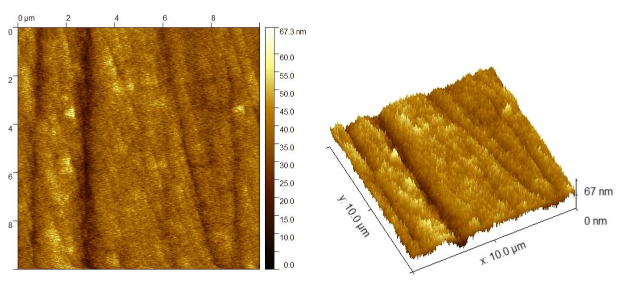
Sample as it is		
	Average	S.D.
Ra	0,4 µm	0,0 µm
Rz	1,98 µm	0,04 µm
RzISO	2,04 µm	0,1 µm



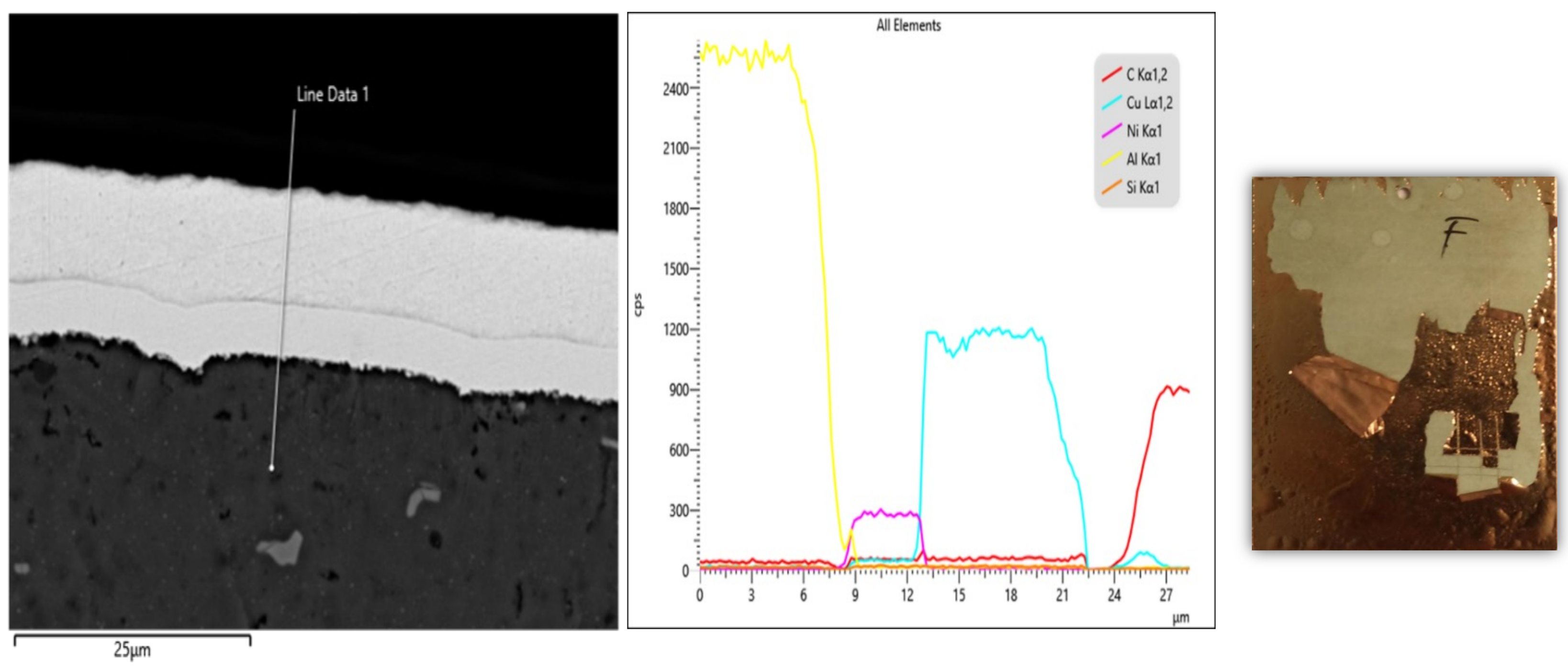
Polished sample		
	Average	S.D.
Ra	0,0 µm	0,0 µm
Rz	0,4 µm	0,06 µm
RzISO	0,4 µm	0,06 µm

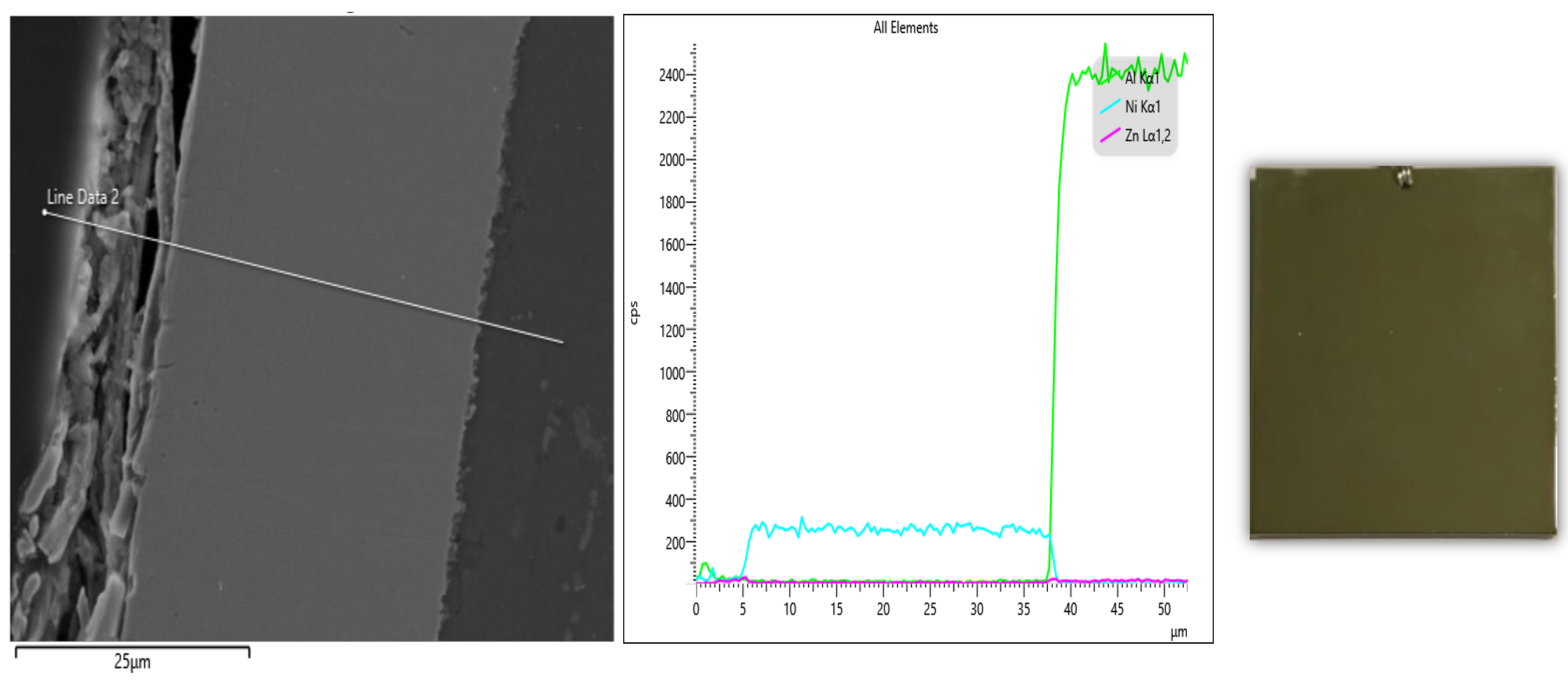


Sq	6.55239 nm
Sa	5.09525 nm



Both samples were chemically degreased and etched with proprietary solutions. Afterwards, a double zincate step was performed [5], followed by a deposition of a thick layer of nickel from a Watts nickel bath. Unpolished sample also underwent a copper plating step, with the purpose of further protecting the underlying structure. Samples were indeed eventually cut for SEM analysis. The sheltering effect was obtained for the polished sample by just prolonging the nickel deposition. Scanning Electron Microscope highlighted how a base material slightly rough surface allows to obtaining good adhesion when electroplating, differently from a highly rough surface. Indeed, by analyzing the unpolished plated sample, the EDS spectrum shows low signal overlapping between Al and Ni X-ray emission, which means poor adhesion between layers (Zn layer is too thin to be observed). Moreover, by performing the tape-test after cross-cutting the sample, data is confirmed since detachment between galvanic layers occurred. By performing the same test on a mechanically polished aluminum sample after electroplating, emission spectrum shows a greater extension of overlapping and the tape test does not give rise to detachment between layers.





Two samples of Al6082 with different surface roughness were chemically treated, galvanized and analyzed. Highly rough surface sample turned out to show poor adhesion whereas polished sample showed the opposite, highlighting how the samples preparation has a tremendous impact when it comes down to electroplating aluminum. Experiments were repeated twice to furhter confirm data.

References

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Acknowledgements

Regional POR CreO FESR 2014-2020 “A.C.A.L. 4.0” project (3553.04032020.158000165_1385) is acknowledged for funding support.

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