Porous anodisation of a novel AM aluminium alloy

Graduate

Rene Pfister

Introduction: Aluminium (Al) alloys are used extensively nowadays in diverse industries ranging from automotive, aerospace, semiconductor and vacuum industries. In the vacuum industry, hard anodisation, an electrochemical coating process, is widely used as a surface treatment for Al, because it provides corrosion protection, insulating properties, good vacuum performance and wear resistance. A typical hard anodising process is shown in Fig. 1. One of the main challenges remains that the growth of the anodised Al oxide (AAO) layer is significantly influenced by the alloying elements present in the alloys. The most commonly used Al alloys in the vacuum industry, 5xxx and 6xxx and their additive manufactured (AM) pendant, AlSix alloys, contain silicon (Si). This prevents the growth of homogeneous insulating AAO layers because it induces voids and cracks in the layer, which affects their properties. This thesis investigates the hard anodising behaviour of a newly developed Al alloy for AM as a possible replacement for conventional cast 6xxx and AM AlSix alloys. The main objective is to better understand which factors affect the growth of porous AAO layers.

Result: AAO layers formed on 6061 alloy and on the new AM alloy under the same anodising conditions show similar growth rate under galvanostatic control and comparable nanomechanical and eletrical properties. The porous AAO is then typically sealed in hot water. The change from Al oxide to hydroxide allows sealing of the pores, which results in improved corrosion resistance of the layer. It is worth noting that cracks were observed on the AAO layers after sealing, as shown in Fig. 2.
Those AAO layers, developed in the lab, were compared to industrially grown AAO layers. No significant difference in their properties were observed. However, it is worth mentioning that the industrial AAO layers were grown faster without drastic lost of quality. This shows that the lab procedure can still be improved.
The surface quality, in particular for AM parts, affects the AAO growth. This study confirms that the AAO layers formed on as-built surfaces are much more defective than those formed on machined ones (Fig. 3), leading to inferior vacuum performance and reduced corrosion resistance. This shows that surface post-processing is needed to achieve good AAO properties.

Conclusion: The composition used in the new AM alloy facilitates the anodisation and has a very similar anodisation behaviour than the conventional 6061 alloy. In addition, the absence of large precipitates leads to fewer defects, such as pits and voids. Crazing and cracking in the AAO layer can still be observed above a certain layer thickness, due to the crystallographic difference between the AAO (amorphe) and the substrate (crystalline). They can also form during sealing due to the differences in thermal expansion. The presence of cracks will reduce the corrosion resistance of the AAO layer as well as its vacuum and electrical performance. A strategy to minimise their formation needs therefore to be developed. Since the processes for vacuum technologies are getting more demanding, the stability of the layers under harsher environments needs to be further evaluated.

Fig. 1: Schematic illustration of the hard anodising process
J. M. Runge, Springer International Publishing AG, 2018

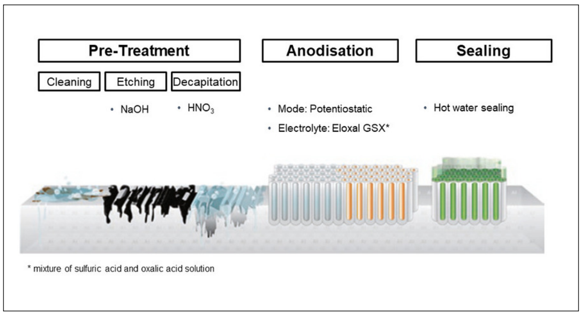


Fig. 2: Scanning electron microscope (SEM) images of top view and cross section of hard anodised coatings:
(a-b) 6061 alloy and (c-d) new alloy

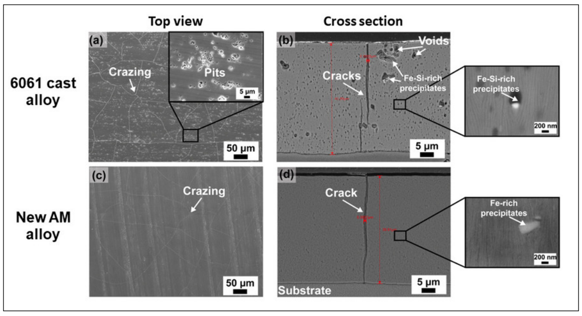
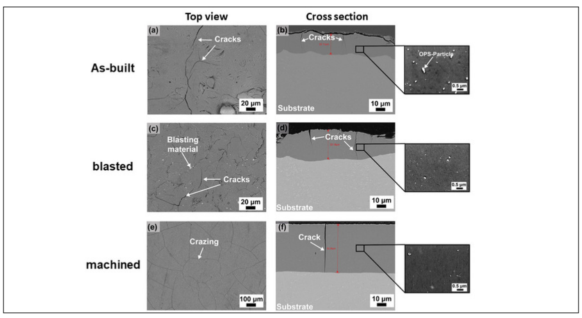


Fig. 3: SEM images of top view and cross section of hard anodised coatings on new AM alloy with surface condition:
(a-b) as-built, (c-d) blasted and (e-f) machined



Advisor
Prof. Dr. Cord Henrik Surberg

Co-Examiner
Dr. Noémie Ott

Subject Area
Mechanical Engineering

Project Partner
Dr. Jürgen Zeschky, VAT / Dr. Sergej Brotzmann, VAT