

The dissolution of aluminium oxide from the barrier layer ~~takes place at the oxide/electrolyte interfaces and leads to the pore nucleation where it was~~ occurs at the oxide/electrolyte interface, forming ~~, followed by the pore nucleation, where it almost~~ happened at the highest field region first. As observed ~~in stage III depicted in Figure 4.1~~ ~~Figure Figure 4.1~~, the current density ~~starts to increase~~ increases at the beginning of stage III due to the dissolution of alumina oxide to form the pore nucleation (Abd-Elnaiem & Gaber, 2013). Barrier oxide and pores ~~were continuously grown~~ consistently grow ~~grow over time~~ until stage IV, where the maximum thickness of barrier oxide of the pore bottom was obtained. ~~An At stage V~~ After a period of time, an equilibrium state has been reached ~~at stage V, at stage V~~ where ~~a constant~~ the current density ~~was recorded~~ was constant, as observed in ~~Figure 4.1~~ ~~Figure Figure 4.1~~. At this stage, a stable formation of AAO nanoporous structure was formed, ~~in which~~ ~~where a~~ high yield pores regularity can be adjusted by time (C. K. Chung et al., Liao, Chang, & Lee, 2011; Mahmud et al., 2015). ~~By extending the anodization process, the thickness of pore bottoms will remain constant meanwhile nanoporous length will continuously increase~~ Extending the ~~A longer~~ anodization process allows the nanoporous length to increase while maintaining the thickness of pore bottoms ~~to remain constant while nanoporous length increases~~. In the meantime ~~The~~, the top surface of the grown AAO exhibits high surface roughness ~~because since~~ the nanoporous was grown from the pore bottom, ~~which was~~ located inside the barrier oxide layer. Hence, in order to ~~To~~ reveal ~~examine~~ the AAO nanoporous structure underneath, further etching must be conducted to remove the ~~top rough~~ rough top surfaces.

The mechanism of ~~the anodization~~ anodisation process can be represented by three elemental reactions as follows: (Chi-Lu & Zhi-Chen, 2011; Lee & Park, 2014; Thamida & Chang, 2002; C-H Voon et al., 2014):

- (i) Dissociation of water molecules ~~diffuse~~ through the oxide/electrolyte interface
- (ii) Reaction at the metal/oxide interface.
- (iii) Reaction at the oxide/electrolyte interface.

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Generally Overall, most of the AAO growth mechanism models agree that the cations and anions move freely, diffuse through the dense oxide layer by the driving force of the electric field (Chi-Lu & Zhi-Chen, 2011). Cations and anions here Here, cations and anions were referred to the Al^{3+} (from the solid Al) and O^{2-} or OH^- (from the aqueous solution, H_2O), respectively referred to the Al^{3+} (from the solid Al) and O^{2-} or OH^- (from the aqueous solution, H_2O). When the electric field was applied, since the size of the OH^- anion (0.153 nm) and O^{2-} anion (0.140 nm) were almost the same, OH^- could easily quickly diffuses from the electrolyte solution, into the dense barrier oxide layer towards the oxide/metal interface (O'Sullivan & Wood, 1970; C.-H. Voon et al., 2013) due. This is due to the similar size of the OH^- anion (0.153 nm) and O^{2-} anion (0.140 nm). -At the metal/oxide interface, Al was oxidized oxidised and into Al^{3+} cations and were released from the Al solid. As shown in Eq. 4.2, electrons were also released together with Al^{3+} ions. The release of electrons produced generating anodizing anodising current, and was measured as the current density. By the time At the same time, the The increasing release of cations was increased, resultings and results to in the an unbalanced system. Hence, once the After the anions were diffused into the metal/oxide interface, the system will became regained balanced again through via the chemical reaction depicted describe in Eq. 4.5 to form insoluble Al_2O_3 compound. On the other hand, H^+ cations were released at the cathode as the H_2 gas.

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During an prolonged anodization anodisation process, the electric field was continuously distributed all over at the oxide surfaces consistently. The magnitude of the electric field would be strongest most substantial at the area which having with maximum surface roughness and concavity defects. Due to the higher electric field and the addition of acidic electrolyte solution. With the influence of higher electric field and an addition of acidic electrolyte solution, Al^{3+} cations were ejected into the electrolytic solution through the oxide/solution interface. The dissolution rate of Al^{3+} cations was substantially faster at the pore bottom s Since the magnitude of the electric field at the pore bottom was more concentrated than the pore wall, therefore, the dissolution rate of Al^{3+} cations were dissolution rate of Al^{3+} cations was substantially faster at the pore bottom. Hence, the growth rate of porous structures on the pore bottom was higher than those at the pore wall. It is also noted that Interestingly, the Al^{3+} cations were ejected directly into the electrolytic solution and were they were not taking part not involved used in producing

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new oxide species at the oxide/electrolyte interface due to the ~~formation of~~ barrier oxide ~~formation had been taken placed~~ at the metal/oxide interface (C. Cheng & Ngan, 2015; Cherki & Siejka, 1973).

~~From the current density versus time transient graph in Figure 4.1~~In summary, the synthesized AAO thin film electrode produced from Al thin film has fulfilled the theoretical concept and agrees with other ~~findings~~ literature that used Al foil, Al alloy or Al electrode. ~~In summary, even though Al thin film electrode was used for this study to grow AAO instead of Al foil, Al alloy or Al electrode, however, the synthesized AAO thin film electrode in this study has fulfilled the theoretical concept and therefore in good conformance to other published articles in the literature. Therefore, based~~The on the trends of the ~~current density graph~~current density graph trends obtained in this study ~~Figure 4.1, it was conclusive~~indicates suggest that the AAO nanoporous structure has been successfully synthesized by the ~~single step anodization~~single-step anodization has successfully synthesized the AAO nanoporous structure. ~~To prove this, A further study on eharacterizations~~characterisations on the crystallinity structure and morphological observation on the ~~synthesized~~synthesised AAO thin film electrode ~~will be~~was conducted. The ~~findings were~~are presented and discussed in Section 4.3. ~~Before the analysis, the AAO thin electrode must undergo a pore widening etching process. -The details and results of the process are presented in section 4.2.~~