CLAIMS

[Claim 1]. A method for electropolishing a manufactured metallic article, the method comprising:

contacting the metallic article with an electropolishing electrolyte; and

electropolishing the metallic article in the electropolishing electrolyte through the application of an applied current regime comprising:

at least one electropolishing regime, each electropolishing regime comprising a current density of at least 2 A/cm^2 and a voltage comprising a shaped waveform having a frequency from 2 Hz to 300 kHz, a minimum voltage of at least 0 V and a maximum voltage of between 0.5 to 500 V.

[Claim 2]. A method according to claim 1, wherein each electropolishing regime is carried out with a current density of 2 A/cm^2 to 200 A/cm^2, preferably 20 to 50 A/cm^2, more preferably greater than 25 A/cm^2.

[Claim 3]. A method according to any preceding claim, comprising at least two, preferably at least three electropolishing regimes, wherein at least one of: the frequency, current density, or maximum voltage of each electropolishing regime is changed compared to the preceding electropolishing regime.

[Claim 4]. A method according to claim 3, wherein each successive electropolishing regime has at least one of: generally lower maximum voltage or generally lower current density than the preceding electropolishing regimes.

[Claim 5]. A method according to claim 3 or 4, wherein the electropolishing step includes at least 4 electropolishing regimes, preferably at least 10 electropolishing regimes, more preferably at least 20 electropolishing regimes.

[Claim 6]. A method according to any one of claims 3 to 5, wherein each electropolishing regime is applied for a duration of 1 to 30 s, preferably 2 to 20 s, more preferably 2 to 15 s.

[Claim 7]. A method according to any one of claims 3 to 6, wherein the electropolishing step includes at least one cooling regime comprising lowering the current density following at least one electropolishing regime.

[Claim 8]. A method according to claim 7, wherein the current density is lowered to be 0.5 or less the current density of the preceding electropolishing regime.

[Claim 9]. A method according to any one of claims 3 to 8, wherein the electropolishing step includes application of an applied current regime comprising:

an initial pulse comprising a current density of at least 2 A/cm^2 and a voltage comprising a shaped waveform having a frequency from 20 to 300 kHz, a minimum voltage of at least 0 V and a maximum voltage of between 50 to 500 V, and applied for a duration of at least 1 s; followed by

at least two electropolishing regimes comprising a current density of at least 2 A/cm^2 and a voltage comprising a shaped waveform current having a frequency from 2 Hz to 300 kHz, a minimum voltage of at least 0 V and a maximum voltage of between 0.5 to 500 V and wherein the frequency and/or maximum voltage of each electropolishing regime is changed compared to the preceding electropolishing regime.

[Claim 10]. A method according to claim 9, wherein the initial pulse has a current density of 2 A/cm^2 to 200 A/cm^2, preferably 20 to 50 A/cm^2, more preferably greater than 25 A/cm^2.

[Claim 11]. A method according to any one of claims 9 or 10, wherein the voltage of the initial pulse is greater than the voltage of each of the successive electropolishing regimes.

[Claim 12]. A method according to any one of claims 9 to 11, wherein the current density of the initial pulse is greater than the current density of each of the successive electropolishing regimes.

[Claim 13]. A method according to one of claims 9 to 12, wherein the applied frequency of the alternating voltage of the initial pulse is different to the applied frequency of each of the successive electropolishing regimes.

[Claim 14]. A method according to any one of claims 9 to 12, wherein the initial pulse is applied for a duration of 2 to 10 s, preferably 2 to 7 s, more preferably 2 to 5 s.

[Claim 15]. A method according to any one of claims 3 to 14, wherein each successive electropolishing regime has a different frequency.

[Claim 16]. A method according to any preceding claim, wherein the shaped waveform comprises one of square wave, sinusoidal, pulsed, or a combination thereof.

[Claim 17]. A method according to any preceding claim, wherein the shaped waveform current comprises a pulsed width modulation (PWM) waveform, preferably a square wave pulse, preferably having a variable dead time.

[Claim 18]. A method according to any preceding claim, wherein the shaped waveform current has a frequency from 10 to 300 kHz, preferably 10 to 200 kHz, more preferably 20 to 100 kHz.

[Claim 19]. A method according to any preceding claim, wherein the waveform comprises a change between the maximum voltage and the minimum voltage of at least one of:
greater than 80% of the maximum voltage; or
greater than 1 V.

[Claim 20]. A method according to any preceding claim, wherein the waveform comprising a change between the maximum voltage and the minimum voltage of at least one of:
greater than 80% of the maximum voltage; or
greater than 5 V.

[Claim 21]. A method according to any preceding claim, wherein the metallic article comprises one of a chromium containing metal alloy, titanium, a titanium alloy, nickel alloys, aluminium or an aluminium alloy.

[Claim 22]. A method according to claim 21, wherein the chromium containing metal alloy is selected from iron-chromium alloys, nickel-chromium (nickel-chrome), nickel-chromium alloys, cobalt-chromium alloys, or cobalt-chromium-molybdenum alloys.

[Claim 23]. A method according to claim 21 or 22, wherein the chromium containing metal alloy comprises a cobalt-chromium alloy or a nickel-chromium alloy.

[Claim 24]. A method according to claim 21, 22 or 23, wherein the chromium containing metal alloy comprises a stainless steel or Inconel.

[Claim 25]. A method according to any preceding claim, wherein the electropolishing electrolyte includes H_3PO_4.

[Claim 26]. A method according to claim 25, wherein the electropolishing electrolyte includes phosphoric acid (H_3PO_4) in combination with sulfuric acid (H_2SO_4), hydrochloric acid (HCl) or combinations thereof, and one of water or a C_1-C_4 alcohol.

[Claim 27]. A method according to any preceding claim, wherein the electropolishing electrolyte comprises phosphoric acid (H_3PO_4) in combination with one of water or a C_1-C_4 alcohol.

[Claim 28]. A method according to any preceding claim, wherein the pH of the electrolyte is from 1.0 to 7.0, preferably from 1.0 to 3.0.

[Claim 29]. A method according to any preceding claim, wherein the electropolishing electrolyte is held at a temperature of -25 to 200 °C, preferably from 0 to 150 °C, more preferably 50 °C to 100 °C, and yet more preferably 60 °C to 90 °C.

[Claim 30]. A method according to any preceding claim, wherein the initial average surface roughness (Ra) of the metallic article is greater than 2 μm, preferably 5 μm, more preferably greater than 10 μm, and more preferably between 10 and 20 μm.

[Claim 31]. A method according to any preceding claim, wherein the initial average surface roughness (Ra) of the metallic article is less than 400 μm, more preferably less than 300 μm, most preferably less than 200 μm.

[Claim 32]. A method according to any preceding claim, wherein the final average surface roughness (Ra) of the metallic article is less than 2 μm, more preferably less than 1.5 μm.

[Claim 33]. A method according to any preceding claim, wherein the rate of material removal is from 1 to 50 μm/min, more preferably from 2 to 30 μm/min.

[Claim 34]. A method according to any preceding claim, wherein the electropolishing electrolyte is contained in an electropolishing cell.

[Claim 35]. A method according to any preceding claim, wherein the electropolishing electrolyte is applied as a fluid flow onto the surface of the metallic article.