We claim:

1. A method of treating an additive manufactured article to increase hardness and corrosion resistance comprising:

treating a shaped additive manufactured self-passivating metal alloy to thereby form an additive manufactured article having:

a treated surface layer; and

a core, wherein at least one of:

the average hardness of the treated surface layer is greater than the average hardness of the core; and

the average corrosion resistance of the treated surface layer is greater than the average corrosion resistance of the core,

wherein the treating includes the sole step of carburizing, nitriding, or nitrocarburizing the metal alloy by exposing the surface layer of the metal alloy to a reagent comprising a guanidine moiety and complexed with HCl at a temperature less than 700 °C.

2. A method of increasing hardness and corrosion resistance in an additive manufactured article, the method comprising treating a shaped additive manufactured self-passivating metal alloy comprising a first surface to form a treated surface layer,

the treated surface layer extending from the first surface to a depth of up to 25 μm below the first surface and having:

a first average hardness and a first average corrosion resistance extending from the first surface to a depth of up to 25 μm below the first surface; and

a core having at least one of:

a second average hardness, wherein the first average hardness is at least 50% greater than the second average hardness; and

a second average corrosion resistance, wherein the first average corrosion resistance is at least 50% greater than the second average corrosion resistance,

wherein the treating includes the sole step of exposing the surface layer of the metal alloy to a reagent comprising a guanidine moiety and complexed with HCl at a temperature less than 700 ℃.

3. The method of claim 2, wherein at least one of:

the first average hardness is 70% or greater than the second average hardness; and

when tested via at least one of Critical Crevice Temperature (CCT) and Cyclic Potentiodynamic Polarization (CPP), the first average corrosion resistance exhibits a lower failure rate than the second average corrosion resistance.

4. The method of any one of claims 1-3, wherein at least one of:

the metal alloy includes at least one of 316L, Alloy 625, Alloy C-22, Alloy C-276, 254SMO, AL6XN, or Alloy 825, another Hastelloy, another nickel alloy, and stainless steel;

the treated surface layer has a carbon concentration of 5 to 15 atomic % and a nitrogen concentration of 5 to 15 atomic % but is substantially free of coarse carbide or nitride precipitates;

the treated surface layer comprises one or more of fine nitride and fine carbide precipitates which at least one of augment and are not deleterious to corrosion resistance.

5. The method of claim 4, wherein at least one of:

the nitrogen in the treated surface layer is present primarily as interstitial nitrogen;

the treated surface layer has a porosity of less than 1%;

the treated surface layer has a porosity of greater than 3%;

the article is subject to hot isostatic pressing (HIP); and

the treated surface layer has a compressive stress of 1 GPa or greater.

6. The method of any one of claims 1-5, wherein

the treated surface layer is produced by one or more of carburizing, nitriding, and nitrocarburizing at less than at least one of 500 ℃, 550 ℃, and 600 ℃,; and

the one or more of carburizing, nitriding, and nitrocarburizing is completed in fewer than at least one of 3 days, 8 hours, and 2 hours.

7. The method of claim 6, wherein the reagent includes at least one of Dimethylbiguanide HCl, Guanidine HCl, Biguanide HCl, Bis(diaminomethylidene)guanidine HCl, and Carbamimidoylimidodicarbonimidic diamide HCl, and optionally further comprising Melamine HCl, an oxygen-free nitrogen halide salt, a non-polymeric N/C/H compound with hydrogen halide association, and a non-polymeric N/C/H compound.

8. The method of any one of claims 1-7, further comprising an untreated surface on one of a channel, groove, or cavity of the article.

9. The method of any one of claims 1-8, wherein the article is subject to one or more of:

stress-relieving before, during, or after the treating;

hot isostatic pressing (HIP) the article before the treating;

bead blasting;

polishing before the treating to at least one of:

reduce a time of carburizing, nitriding, or nitrocarburizing;

improve consistency of hardening, reduce surface porosity, decrease surface roughness, control a morphology of the treated layer; and

improve consistency of hardening, reducing surface porosity, decreasing surface roughness, and controlling a morphology of the treated layer; and

shaping via at least one of laser powder bed fusion (PBF), metal injection molding (MIM), powder injection molding (PIM), sintered metal processes, binder jetting, wire arc additive manufacturing, e-beam melting, sheet lamination, and directed energy deposition (DED).

10. The method of any one of claims 1-9, wherein the surface treatment is applied during additive manufacturing.

11. The method of any one of claims 1-10, wherein the metal alloy comprises 10-40 wt% nickel based on the total weight of the alloy.

12. The method of any one of claims 1-11, wherein, when subjected to Critical Crevice Temperature (CCT) testing, the treated surface exhibits a lower failure rate than the core.