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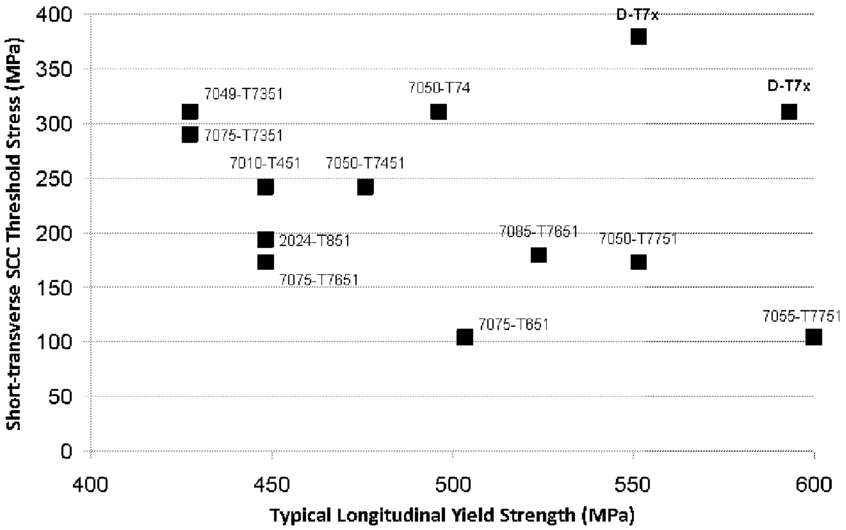

FIG. 1

(57) Abstract: The disclosure relates to an alloy comprising, by weight, about 5.8% to about 6.8% zinc, about 2.5% to about 3.0% magnesium, about 1.5% to about 2.3% copper, 0% to about 0.2% scandium, 0% to about 0.2% zirconium, and optionally less than about 0.50% silver, the balance essentially aluminum and incidental elements and impurities. In embodiments, the alloy has a stress-corrosion cracking threshold stress of at least about 240 MPa using an ASTM G47 short-transverse test specimen and a yield strength of at least about 510 MPa using an ASTM E8 longitudinal test specimen.

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ALUMINUM ALLOYS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority to U.S. Provisional Patent Application No. 61/488,713, filed May 21, 2011, the content of which is incorporated herein by reference in its entirety.

FEDERALLY-SPONSORED RESEARCH AND DEVELOPMENT

[0002] Activities relating to the development of the subject matter of this invention were funded at least in part by U.S. Government, Office of Naval Research Contract Nos. N00014-09-M-0400 and N00014-11-C-0080, and thus the U.S. may have certain rights in the invention.

BACKGROUND

[0003] Aluminum alloys, such as the 7XXX Al-Zn-based alloys, are commonly used in structural applications demanding high specific strength. For example, the commercial aluminum alloy 7050 is widely used for aerospace applications. When aged to near the peak of strength, commercial aluminum alloys are susceptible to stress-corrosion cracking (SCC). Thus, there has developed a need for aluminum alloys which show a high strength and yet are resistant to SCC.

SUMMARY

[0004] In an aspect the disclosure relates to an alloy comprising, by weight, about 5.8% to about 6.8% zinc, about 2.5% to about 3.0% magnesium, about 1.5% to about 2.3% copper, 0% to about 0.2% scandium, 0% to about 0.2% zirconium, and optionally less than about 0.50% silver, the balance essentially aluminum and incidental elements and impurities. In embodiments, the alloy has a stress-corrosion cracking threshold stress of at least about 240 MPa using an ASTM G47 short-transverse test specimen and a yield strength of at least about 510 MPa using an ASTM E8 longitudinal test specimen.

[0005] In another aspect the disclosure relates to a method for producing an alloy, the method comprising preparing a melt that includes, by weight, about 5.8% to about 6.8% zinc, about 2.5% to about 3.0% magnesium, about 1.5% to about 2.3% copper, 0% to about 0.2% scandium, 0% to about 0.2% zirconium, and optionally less than about 0.50% silver, the balance essentially aluminum and incidental elements and impurities. In embodiments of the method, the melt can be cooled to room temperature. In further embodiments of the method, the alloy is homogenized by heating it from room temperature to 400°C at 1°C per minute, holding it at 400°C for 12 hours, heating it from 400°C at 1°C per minute, and holding it at 460°C-480°C for 24-48 hours.

[0006] In another aspect the disclosure relates to a method for producing an alloy that comprises an aluminum matrix. The method comprises adding to the aluminum matrix amounts of zinc, magnesium, and copper according to an SCC index of the equation: (SCC index) = $2\times\text{wpZn} + \text{wpMg} - \text{wpCu}$ where wpZn, wpMg, and wpCu are the weight percentages of Zn, Mg, and Cu, respectively, in the matrix of the alloy. In embodiments, the SCC index of the alloy is less than or equal to 1.6.

[0007] Other aspects and embodiments will become apparent in light of the following description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Fig. 1 is a graph plotting short-transverse SCC threshold stress and typical longitudinal yield strength of some embodiments of alloys in comparison to conventional aluminum alloys.

[0009] Fig. 2 is a graph plotting maximum applied stress as a function of life (cycles to failure) of one of the embodiments of Fig. 1 in comparison to a conventional aluminum alloy.

DETAILED DESCRIPTION

[0010] Aspects relate to an alloy as described herein. Surprisingly the inventors have produced aluminum alloys that exhibit improved physical properties relative to existing aluminum alloys, and have developed methods for making the same. It should be understood that the claims are not limited in application to the details of construction and the arrangements of the components set forth in the following description. Other aspects and embodiments will be apparent in light of the following detailed description.

[0011] As used herein, terms such as $L1_2$ phase, fracture toughness (K_{Ic}), and stress-corrosion-cracking resistance (K_{ISCC}) include definitions that are generally known in the art such as those found in ASM MATERIALS ENGINEERING DICTIONARY (J.R. Davis ed., ASM International 1992).

[0012] "Homogenizing" as used herein refers to a process in which high-temperature soaking is used at a suitable temperature for a suitable dwell time to reduce chemical or metallurgical segregation, which occurs as a natural result of solidification in some alloys. In some embodiments, the high-temperature soaking is conducted for a dwell time of about 8 hours to about 48 hours.

[0013] "Extrusion" or "extruding" as used herein refers to a conversion of a metal ingot or billet into lengths of uniform cross section by forcing the metal to flow plastically through a die orifice.

[0014] "Aging temperature" as used herein refers to an elevated temperature at which an alloy is kept for heat treatment. Such heat treatment may suitably induce a precipitation reaction. In some embodiments, the heat treatment may be conducted at two distinct temperatures for two distinct times.

[0015] "Yield strength" as used herein refers to the stress level at which plastic deformation begins.

[0016] Any recited range described herein is to be understood to encompass and include all values within that range, without the necessity for an explicit recitation.

[0017] Aspects of the disclosure relate to aluminum alloys which show acceptably high strength and yet are resistant to SCC. Without being necessarily limited by any mechanism or mode of operation, it may be that segregation of zinc to grain boundaries in aluminum alloys can make the alloy susceptible to SCC. According to one aspect, the disclosed alloys can minimize the elemental segregation of zinc to the grain boundaries, and thereby reduce the susceptibility of the alloy to SCC. It is contemplated that segregation of zinc to the grain boundaries in Al-Zn-based alloys can be prevented by using the zinc to instead form the $MgZn_2$ phase. The $MgZn_2$ phase forms both within the grain and at the grain boundary, as either discrete or linked particles.

[0018] In the course of this work, an "SCC index" was developed, and it was determined that compositions that minimize the SCC index are generally effective in minimizing the segregation of zinc to the grain boundaries. This index is as follows:

$$\text{(SCC index)} = 2\times\text{wpZn} + \text{wpMg} - \text{wpCu} \qquad \textbf{[1]}$$

where wpZn, wpMg, and wpCu are the weight percentages of Zn, Mg, and Cu, respectively, in solution in the matrix of the alloy. The SCC index is calculated at the aging temperature, and is based on the equilibrium composition of the aluminum matrix at the aging temperature, after accounting for the phase fraction of precipitates present at the aging temperature. The matrix composition can be computed with any suitable thermodynamic database and calculation packages such as Thermo-Calc® software version N offered by Thermo-Calc Software (McMurray, PA).

[0019] According to one aspect, an alloy can be produced by adding zinc, copper, and magnesium to an aluminum matrix, in amounts calculated using the SCC index, such that the SCC index is maintained at or below about 1.6 (e.g., about 1.6, about 1.5, about 1.4, about 1.3, about 1.2, about 1.1, about 1.0, about 0.9, about 0.8, about 0.7, about 0.6, about 0.5, about 0.4, about 0.3, about 0.2, about 0.1, or less). The alloy may contain other components and/or additives, including other components and/or additives as specified herein, and may be further processed using a variety of processing techniques known in the art, and also including the processing techniques described herein, such as press-forging, homogenizing, aging, and the like.

[0020] In one embodiment, the alloy can be first homogenized after solidification from the melt by heating it from room temperature to 400°C at 1°C per minute, holding it at 400°C for 12 hours, heating it from 400°C at 1°C per minute, and holding it at 460°C-480°C for 24-48 hours. The homogenized alloy can then, in another embodiment, be hot-worked, e.g., extruded to a change in cross section, then solution heat-treated at 460°C-480°C for 1-4 hours, then aged at a first temperature of 100°C–120°C for 6–12 hours, then heated to a second temperature of 160°C–180°C and held at the second temperature for 8–30 hours, and quenched with water. These heat treatments can assist in forming the η-$MgZn_2$ phase as discrete particles rather than linked particles, as explained further herein. In other embodiments, different homogenization, forging, aging, and/or other forming or heat treatment techniques may be used. In further embodiments, the alloy may be optionally subjected to a stress-relief treatment between the solution heat-treatment and the aging heat-treatment. The stress-relief treatment can include stretching the alloy, compressing the alloy, or combinations thereof.

[0021] According to a further aspect, the disclosed alloys incorporate dispersoid forming elements in amounts sufficient to inhibit recrystallization. Such dispersoid formers may include scandium and zirconium. To this end, the dispersoid formers may form dispersed $L1_2$ phase particles in the alloy, wherein the $L1_2$ phase constitutes about 0.1% by volume of the alloy.

[0022] According to a still further aspect, the alloys are hardened by the η-$MgZn_2$ phase. The η-$MgZn_2$ phase may constitute about 3% to about 8% by volume of the alloy. The η-$MgZn_2$ phase may form within grains and/or at grain boundaries, and may form as discrete particles and/or linked particles. Linked particles are often more likely to form at grain boundaries, adversely affecting the SCC resistance. Accordingly, in one embodiment, the alloy contains η-$MgZn_2$ that is formed primarily as discrete particles. Various heat treatments that are known in the art or otherwise disclosed herein can be used to guide the formation of η-$MgZn_2$ as discrete particles, rather than linked particles.

[0023] According to one embodiment, the composition of an alloy includes, by weight, about 5.8% to about 6.8% zinc, about 2.5% to about 3.0% magnesium, about 1.5% to about 2.3% copper, 0% to about 0.2% scandium, 0% to about 0.2% zirconium, and optionally less than about 0.50% silver, the balance essentially aluminum and incidental elements and impurities. In one embodiment, the alloy may include the elements in the nominal composition, as well as additional elements; in another embodiment, the alloy may consist essentially of the elements in the nominal composition; and in a further embodiment, the alloy may consist only of the elements in the nominal composition. Incidental elements and impurities in the disclosed alloys may include, but are not limited to, silicon, iron, chromium, nickel, vanadium, titanium, or mixtures thereof, and may be present in the alloys disclosed herein in amounts totaling no more than 1%, no more than 0.9%, no more than 0.8%, no more than 0.7%, no more than 0.6%, no more than 0.5%, no more than 0.4%, no more than 0.3%, no more than 0.2%, no more than 0.1%, no more than 0.05%, no more than 0.01%, or no more than 0.001%. Additionally, in one embodiment, the alloy has a predominately face-centered cubic crystal structure, with additional phases and precipitates, such as those disclosed herein.

[0024] In one embodiment, the alloy has a stress-corrosion cracking threshold stress of at least about 240 MPa using an ASTM G47 short-transverse test specimen and a yield strength of at least about 510 MPa using an ASTM E8 longitudinal test specimen. ASTM G47 covers the test method of sampling, type of specimen, specimen preparation, test environment, and method of exposure for determining the susceptibility to SCC of aluminum alloys. ASTM E8 covers the testing apparatus, test specimens, and testing procedure for tensile testing.

[0025] Some samples exemplary of embodiments of the alloy disclosed herein were prepared and tested for physical properties. Additionally, a counter-example (alloy B) was also prepared and tested for comparison. These examples are described in greater detail below as illustrative non-limiting embodiments.

EXAMPLE 1: alloy A

[0026] A melt for alloy A was prepared by heating a charge of starting materials, the charge having the nominal composition of 6.3 Zn, 2.7 Mg, 1.6 Cu, 0.10 Sc, 0.05 Zr, and balance Al, in wt%. The alloy includes a variance in the constituents in the range of plus or minus ten percent of the nominal (mean) value. The melt weighed about 450 grams. After being cooled to room temperature, the alloy was homogenized by heating it from room temperature to 460°C at 1°C per minute and holding it at 460°C for 8 hours. The homogenized alloy was press-forged down to 50% reduction in height, to about 5 cm in short-transverse thickness. Specimens were excised in the short-transverse direction to measure the fracture toughness, K_{Ic}, and the SCC resistance, K_{ISCC}.

[0027] The excised specimens were aged at 107°C for 6 hours, then heated to 177°C and held at 177°C for 8 hours, and quenched with water. This aging heat-treatment is also called the "T7x" heat treatment hereinafter. During the SCC test, the specimens were coupled to the stainless steel 17-4PH in a 3.5% NaCl solution. Because the specimens were notched by machining instead of conventional pre-cracking, the measured K_{Ic} and K_{ISCC} values were appropriately discounted. In a head-to-head comparison, alloy A was found to have hardness better than that of 7050, and an SCC resistance about 2.4 times greater than that of 7050, as shown in the following Table 1. Table 1 also indicates the SCC Index of the alloy, calculated using the equation above. The alloy 7050 was subjected to a heat treatment identical to alloy A and was tested using the same procedures. The tensile strength was also measured, and the results are listed in Table 2.

EXAMPLE 2: alloy B

[0028] A melt for alloy B was prepared by heating a charge of starting materials, the charge having the nominal composition of 6.5 Zn, 1.5 Mg, 1.6 Cu, 0.50 Ag, 0.10 Sc, 0.05 Zr, and balance Al, in wt%. The melt weighed about 450 grams. Alloy B is a counterexample. Although alloy B includes Zn and Cu in amounts similar to alloy A, the lower Mg content raises the SCC index, undesirably lowering K_{ISCC}. A comparison of the properties of alloy B and 7050 is shown in Table 1. Table 1 also indicates the SCC Index of the alloy, calculated using equation [1] above.

The alloy 7050 was subjected to a heat treatment identical to alloy B, which was also identical to the heat treatment and processing described above with respect to alloy A (EXAMPLE 1). The tensile strength was also measured, and the results are listed in Table 2.

EXAMPLE 3: alloy C

[0029] A melt for alloy C was prepared by heating a charge of starting materials, the charge having the nominal composition of 5.8 Zn, 3.0 Mg, 2.2 Cu, 0.05 Sc, 0.05 Zr, and balance Al, in wt%. The alloy C includes a variance in the constituents in the range of plus or minus ten percent of the nominal (mean) value. The melt weighed about 450 grams. After being cooled to room temperature, the alloy was homogenized by heating it from room temperature to 460°C at 1°C per minute and holding it at 460°C for 8 hours. The homogenized alloy was press-forged down to 50% reduction in height, to about 4 cm in short-transverse thickness. Specimens were excised in the short-transverse direction to measure the K_{Ic} and K_{ISCC}. The excised specimens were aged at 107°C for 6 hours, then heated to 177°C and held at 177°C for 8 hours, and quenched with water. During the SCC test, the aluminum specimens were coupled to the stainless steel PH17-4 in a 3.5% NaCl solution. In a head-to-head comparison, alloy C was found to have hardness better than that of 7050, and also an SCC resistance better than that of 7050, as shown in Table 1. Table 1 also indicates the SCC Index of the alloy, calculated using equation [1] above. The alloy 7050 was subjected to a heat treatment identical to alloy C. The tensile strength was also measured, and the results are listed in Table 2.

Table 1

	Calculated SCC Index	Calculated phase fraction of η-$MgZn_2$	Converted K_{ISCC} (MPa$\sqrt{m}$)	Converted K_{Ic} (MPa$\sqrt{m}$)	K_{ISCC} / K_{Ic}	Vickers hardness number
Alloy A	1.5	0.07	32.3	32.7	0.99	165
Alloy B	3.2	0.05	13.3	31.5	0.42	152
Alloy C	1.5	0.08	15.9	20.7	0.77	177
7050	1.9	0.08	13.3	34.1	0.39	157

Table 2

	0.2% Yield Stress (MPa)	Ultimate Tensile Stress (MPa)	Elongation (%)	Reduction of Area (%)
Alloy A	370±30	370±30	3	5
Alloy B	350±70	380±90	8±2	13±9
Alloy C	470	500	5	4
7050	410±40	430±30	4±1	5±3

[0030] As seen from Tables 1 and 2, the alloys according to the disclosed aspects and embodiments (e.g., alloys A and C) produce physical properties that are comparable or superior to those of alloy 7050, and in particular, the alloys A and C have a lower SCC Index compared to alloy 7050, which indicates a superior resistance to SCC. For alloy A, the hardness is superior to that of alloy 7050, and the SCC resistance is also superior to alloy 7050. Additionally, the fracture toughness (K_{Ic}), yield stress, ultimate tensile stress, and ductility are all comparable to those of alloy 7050. For alloy C, the hardness, yield stress, ultimate tensile stress, and SCC resistance are superior to those of alloy 7050, and the ductility is comparable. The fracture toughness (K_{Ic}) of alloy C was found to be slightly lower than that of alloy 7050. It is noted that the K_{ISCC} of alloys A and C are very close to the theoretical limit (i.e. the K_{Ic} value).

EXAMPLE 4: alloy A-1

[0031] A melt was prepared by heating a charge of starting materials, the charge having the nominal composition of 6.3 Zn, 2.7 Mg, 1.6 Cu, 0.12 Zr, and balance Al, in wt%, which is the same as alloy A. The as-cast alloy A-1 was generally shaped like a cylinder, measuring about 18 cm in diameter and 56 cm in height, and weighing about 50 kg. After being cooled to room temperature, the as-cast alloy A-1 was homogenized by heating it in a furnace from room temperature to 400°C at 1°C per minute, holding it at 400°C for 12 hours, heating it from 400°C at 1°C per minute, and holding it at 460°C-480°C for 24-48 hours. The homogenized alloy A-1 was extruded to a cylindrical billet, reducing the diameter to about 8 cm in diameter. This represents an extrusion ratio of about 5½:1. Specimens were excised and subjected first to a solution heat-treatment ("SHT"), and then to an aging heat-treatment. The solution heat-treatment was conducted by subjecting the specimens to a temperature of 460°C or 465°C for 2 hours. The aging heat-treatment was conducted by subjecting the specimens to 107°C for 6 hours, then heating to 177°C, holding at 177°C for 8 hours, and quenching with water. Tensile strength was measured at room temperature according to ASTM E8 with a longitudinal test specimen. The results are listed in Table 3 in comparison to a conventional aluminum alloy, namely, QT-7050-T74. The yield strength ("YS") of alloy A-1 is about 10% higher than that of QT-7050-T74 in the longitudinal and transverse directions, with comparable elongations and reduction-of-area percentages ("%RA").

Table 3

Properties		QT-7050-T74	A-1 – T7x	
		475°C SHT	465°C SHT	460°C SHT
Longitudinal	UTS (ksi)	79.4	85.5	84.4
	0.2% YS (ksi)	**72.4**	**81.1**	**78.7**
	% elongation	13.5	14	13
	% RA	42.5	39	39.5
Transverse	UTS (ksi)	70.6	76.8	77.2
	0.2% YS (ksi)	**63.4**	**70.5**	**68.8**
	% elongation	4	5	6
	% RA	9.5	6.2	7.8

[0032] The SCC resistance was measured according to a rising step load (RSL) method developed by Lou Raymond & Associates in Newport Beach, CA, generally as follows. Machined notched samples in the fully heat-treated condition were used for the testing. Initial fracture toughness (K_{Ic}) testing was performed in air at a rapid loading rate to first determine the maximum breaking load. The test specimen geometry was changed to increase the amount of constraint. An effective stress intensity K_p was calculated, since the specimen had a machined notch instead of a fatigue pre-crack as required by ASTM E399. Previous testing of 7075-T6 aluminum alloy in a similar way found that the value for K_p was approximately 1.5 times the value for K_{Ic}. Having measured the maximum breaking load, the RSL method was employed to measure the K_{ISCC} of the samples. During the SCC test, the aluminum specimens were anodically charged by coupling them to PH17-4 adapters in a 3.5% salt-water environment. Alloy A-1 showed a K_{Ic} value of 38.8 ksi-in^{½} and a K_{ISCC} value greater than 38 ksi-in^{½}.

EXAMPLE 5: alloy D

[0033] A melt for alloy D was prepared by heating a charge of starting materials, the charge having the nominal composition of 6.3 Zn, 2.7 Mg, 1.6 Cu, 0.12 Zr, and balance Al, in wt%. The alloy D preferably includes a variance in the constituents in the range of plus or minus ten percent of the nominal (mean) value, and is substantially free of scandium. The as-cast alloy D was generally shaped like a cylinder, measuring about 18 cm in diameter and 56 cm in height, and weighing about 50 kg. After being cooled to room temperature, the as-cast alloy D was homogenized by heating it from room temperature to 400°C at 1°C per minute, holding it at 400°C for 12 hours, heating it from 400°C at 1°C per minute, and holding it at 460°C-480°C for 24-48 hours. The homogenized alloy D was extruded to a cylindrical billet, reducing the diameter to about 8 cm in diameter. This represents an extrusion ratio of about 5½:1. Specimens were excised and subjected first to a solution heat-treatment, and then to an aging heat-treatment. The solution heat-treatment was conducted by subjecting the specimens to a temperature of 460°C, 465°C, or 470°C for 2 hours. The aging heat-treatment was conducted according to the T7x heat treatment. Tensile strength was measured at room temperature according to ASTM E8 with a longitudinal test specimen. The results are listed in Table 4 in comparison to the conventional QT-7050-T74. Alloy D has about 20% higher YS than 7050-T74 in the longitudinal direction and about 13% to about 15% higher YS than 7050-T74 in the transverse and 45° direction, with comparable elongations and %RA. The strength values of alloy D represent a significant improvement over 7050-T74.

Table 4

Properties		[illegible]	D – T7x		
		475°C SHT	470°C SHT	465°C SHT	460°C SHT
Longitudinal	UTS (ksi)	79.4	90.9	89.1	90.7
	0.2% YS (ksi)	**72.4**	**86**	**84.7**	**85.3**
	% elongation	13.5	12.5	12.5	13.5
	% RA	42.5	35	37.5	37
Transverse	UTS (ksi)	70.6	79.6	74.5	74.3
	0.2% YS (ksi)	**63.4**	**72.6**	**70**	**70.7**
	% elongation	4	5	4	3.8
	% RA	9.5	5.2	3.1	4.0
45° orientation	UTS (ksi)	69.1	76	73.9	76.3
	0.2% YS (ksi)	**62.1**	**70.5**	**68.9**	**68.6**
	% elongation	5	3.5	4.5	5.9
	% RA	5.6	5.5	5.2	7.3

[0034] The SCC threshold stress of alloy D was measured by a 30-day accelerated stress corrosion testing according to ASTM G47. Short-transverse samples of alloy D were solution heat-treated at 460°C for 2 hours, and heat-treated according to the T7x heat treatment. Fig. 1 shows the SCC threshold stress and typical longitudinal yield strength of alloy D in comparison to conventional aluminum alloys. The samples of alloy D passed a stress level of about 380 MPa, which is above the highest SCC temper designation currently in use, namely, T73. Thus, the combination of strength and SCC resistance of alloy D is substantially improved over that of conventional aluminum alloys.

[0035] The SCC resistance was measured according to the RSL method. Machined notched samples in the fully heat-treated condition were used for the testing. K_{Ic} testing was performed in air at a rapid loading rate to first determine the maximum breaking load. The test specimen geometry was changed to increase the amount of constraint. An effective stress intensity K_p was calculated. Having measured the maximum breaking load, the RSL method was employed to measure the K_{ISCC} of the samples. During the SCC test, the aluminum specimens were anodically charged by coupling them to PH17-4 adapters in a 3.5% salt-water environment. Alloy D specimens that were solution heat-treated at 460°C for 2 hours and heat-treated according to the T7x heat treatment showed a K_{Ic} value of 47.8 ksi-in^{½} and a K_{ISCC} value of 20.0 ksi-in^{½}. On the other hand, alloy D specimens solution heat-treated at 470°C for 2 hours and heat-treated according to the T7x heat treatment showed a K_{Ic} value of 55.4 ksi-in$^{1/2}$ and a K_{ISCC} value of 15.0 ksi-in$^{1/2}$.

[0036] Smooth bar fatigue testing was carried out according to ASTM E466 at four different maximum stress levels: 250 MPa, 280 MPa, 340 MPa, and 400 MPa. An R-ratio, i.e., the ratio of the minimum peak stress to the maximum peak stress, of 0.1 and frequency of 20 Hz was used for the test. Transverse alloy D specimens were solution heat-treated at 470°C and heat-treated according to the T7x heat treatment, and compared to 7050-T74 samples. Fig. 2 shows the maximum applied stress as a function of life (cycles to failure) of alloy D in comparison to 7050-T74. Alloy D shows fatigue behavior comparable to 7050-T74. Notably, at a low stress range, e.g., maximum stress below about 35 ksi (about 250 MPa), the difference in life between alloy D and 7050-T74 is expected to be minimal.

[0037] It is understood that the disclosure may embody other specific forms without departing from the spirit or central characteristics thereof. The disclosure of aspects and embodiments, therefore, are to be considered in all respects as illustrative and not restrictive, and the claims are not to be limited to the details given herein. Accordingly, while specific embodiments have been illustrated and described, numerous modifications come to mind without significantly departing from the spirit of the invention and the scope of protection is only limited by the scope of the accompanying claims. Unless noted otherwise, all percentages listed herein are weight percentages.

CLAIMS

What is claimed is:

1. An alloy comprising, by weight, about 5.8% to about 6.8% zinc, about 2.5% to about 3.0% magnesium, about 1.5% to about 2.3% copper, 0% to about 0.2% scandium, 0% to about 0.2% zirconium, and optionally less than about 0.50% silver, the balance essentially aluminum and incidental elements and impurities, wherein the alloy has a stress-corrosion cracking threshold stress of at least about 240 MPa using an ASTM G47 short-transverse test specimen and a yield strength of at least about 510 MPa using an ASTM E8 longitudinal test specimen.

2. The alloy of claim 1, wherein the alloy comprises dispersed $L1_2$ phase particles including at least one of scandium and zirconium, constituting about 0.1% by volume of the alloy.

3. The alloy of claim 1, wherein the alloy comprises an η-$MgZn_2$ phase that constitutes about 3% to about 8% by volume of the alloy.

4. The alloy of claim 1, wherein the alloy comprises 6.3 Zn, 2.7 Mg, 1.6 Cu, 0.10 Sc, 0.05 Zr, and balance Al, in wt%, with the composition including a variation of ten percent of the nominal values.

5. The alloy of claim 1, wherein the alloy comprises 5.8 Zn, 3.0 Mg, 2.2 Cu, 0.05 Sc, 0.05 Zr, and balance Al, in wt%, with the composition including a variation of ten percent of the nominal values.

6. The alloy of claim 1, wherein the alloy comprises 6.3 Zn, 2.7 Mg, 1.6 Cu, 0.12 Zr, and balance Al, in wt%, with the composition including a variation of ten percent of the nominal values.

7. A method for producing an alloy comprising:

preparing a melt that includes, by weight, about 5.8% to about 6.8% zinc, about 2.5% to about 3.0% magnesium, about 1.5% to about 2.3% copper, 0% to about 0.2% scandium, 0% to about 0.2% zirconium, and optionally less than about 0.50% silver, the balance essentially aluminum and incidental elements and impurities;

cooling the melt to room temperature; and

homogenizing the alloy by heating it from room temperature to 400°C at 1°C per minute, holding it at 400°C for 12 hours, heating it from 400°C at 1°C per minute, and holding it at 460°C-480°C for 24-48 hours.

8. The method of claim 7, further comprising:

hot-working the alloy to a change in cross section.

9. The method of claims 7 or 8, further comprising:

solution heat-treating the alloy at 460°C-480°C for 1-4 hours.

10. The method of any of claims 7–9, further comprising:

aging the alloy at a first temperature of 100°C–120°C for 6–12 hours, then heating the alloy to a second temperature of 160°C–180°C and holding the alloy at the second temperature for 8–30 hours, and quenching the alloy with water.

11. An alloy produced according to the method of any of claims 7–10.

12. A manufactured article comprising an alloy according to any of claims 1–6 and claim 11.

13. A method for producing an aluminum alloy comprising:

providing an alloy comprising an aluminum matrix;

adding to the aluminum matrix amounts of zinc, magnesium, and copper according to an SCC index of the equation:

$$(\text{SCC index}) = 2\times wpZn + wpMg - wpCu$$

where wpZn, wpMg, and wpCu are the weight percentages of Zn, Mg, and Cu, respectively, in the matrix of the alloy, and wherein the SCC index of the alloy is less than or equal to 1.6.

14. The method of claim 13, wherein the alloy comprises about 5.8% to about 6.8% zinc, about 2.5% to about 3.0% magnesium, about 1.5% to about 2.3% copper, 0% to about 0.2% scandium, 0% to about 0.2% zirconium, and optionally less than about 0.50% silver, the balance essentially aluminum and incidental elements and impurities.

15. The method of any of claims 13–14, further comprising:

homogenizing the alloy by heating it from room temperature to 400°C at 1°C per minute, holding it at 400°C for 12 hours, heating it from 400°C at 1°C per minute, and holding it at 460°C-480°C for 24-48 hours.

16. The method of any of claims 13–15, further comprising:

hot-working the alloy to a change in cross section.

17. The method of any of claims 13–16, further comprising:

solution heat-treating the alloy at 460°C-480°C for 1-4 hours.

18. The method of any of claims 13–17, further comprising:

aging the alloy at a first temperature of 100°C–120°C for 6–12 hours, then heating the alloy to a second temperature of 160°C–180°C and holding the alloy at the second temperature for 8–30 hours, and quenching the alloy with water.

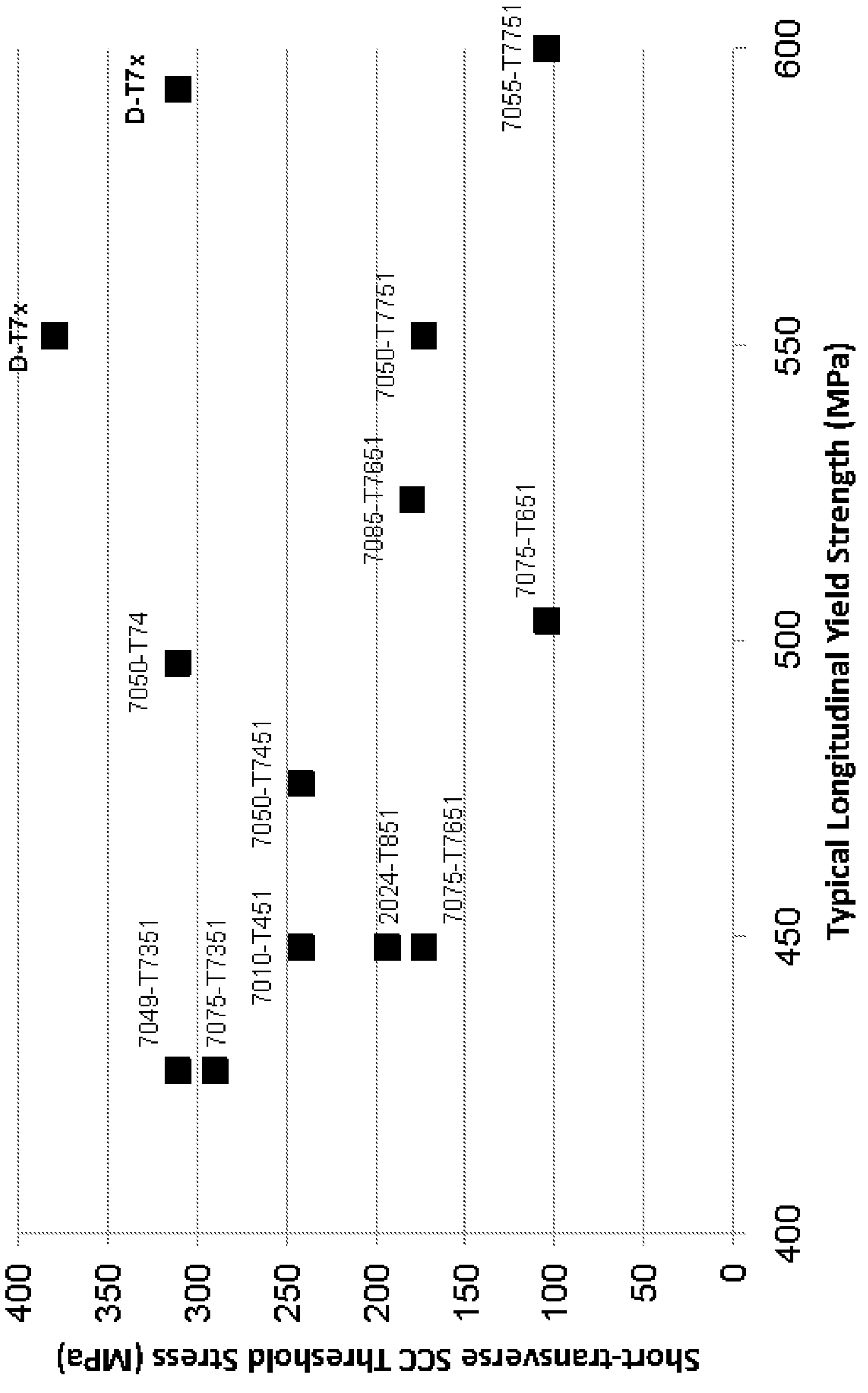
Short-transverse SCC Threshold Stress (MPa)
0
50
100
150
200
250
300
350
400
Typical Longitudinal Yield Strength (MPa)
400
450
500
550
600
7049-T7351
7075-T7351
7010-T451
7050-T7451
2024-T851
7075-T7651
7050-T74
7075-T651
7085-T7651
7050-T7751
D-T7x
D-T7x
7055-T7751

FIG. 1

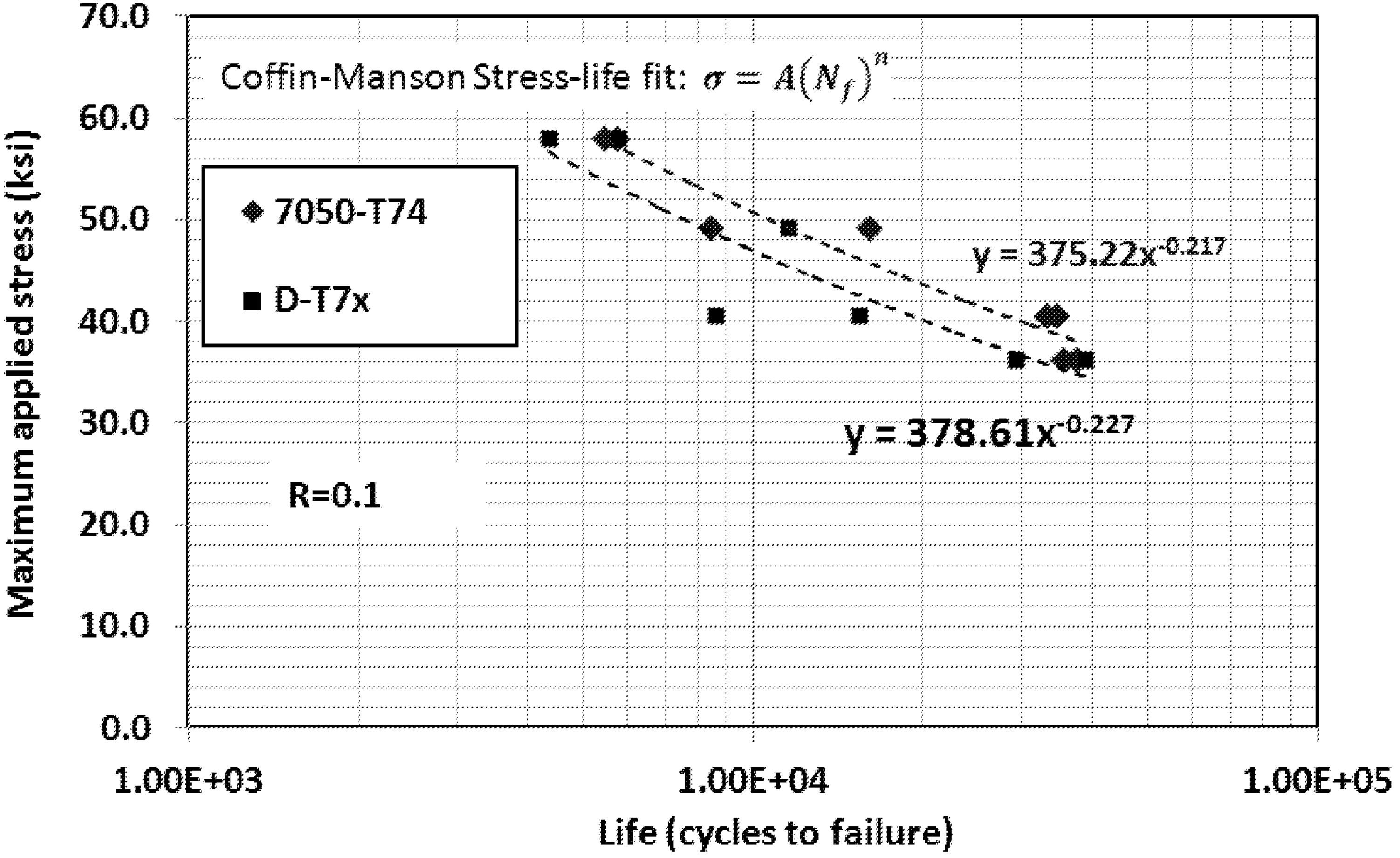
Coffin-Manson Stress-life fit: $\sigma = A(N_f)^n$
7050-T74
D-T7x
$y = 375.22x^{-0.217}$
$y = 378.61x^{-0.227}$
R=0.1
Maximum applied stress (ksi)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1.00E+03
1.00E+04
1.00E+05
Life (cycles to failure)

FIG. 2