Combined microtomography, thermal desorption spectroscopy, X-ray diffraction study of hydrogen trapping behavior in 7XXX aluminum alloys

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Corrigendum to “Combined microtomography, thermal desorption spectroscopy, X-ray diffraction study of hydrogen trapping behavior in 7XXX aluminum alloys” [Mater. Sci. Eng. A 655 (2016) 221-228]

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Abstract

In the article [Materials Science & Engineering A 655 (2016) 221-228], we have identified an error on the estimation of desorption energy for the trapping states in 7XXX aluminum alloys. This corrigendum is intended to correct the error.

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Corrigendum

The authors regret the need of a corrigendum with the following changes:

1. In abstract, Line 3 to Line 8, sentences “It is revealed that micropores are the predominant hydrogen trap site in alloys with medium hydrogen content, whereas grain boundaries is the major hydrogen trap site in alloys with low and high hydrogen content. We have clarified that the rate of trap site occupancy in grain boundaries is high compared to dislocations and vacancies. Such high hydrogen coverage at grain boundaries indicates that the hydrogen-assisted fracture" would be intergranular” should be read as:

“It is revealed that micropores are the predominant hydrogen trap site in alloys with medium hydrogen content, whereas dislocation is the major hydrogen trap site in alloys with low and high hydrogen content. We have clarified that the rate of trap site occupancy in dislocations is high compared to grain boundaries and vacancies.”

2. In page 226, Fig. 7 with caption “Relationship between $\ln\left(\frac{\varphi}{T_2^2}\right)$ and ${}^{1}/{T_m}$ corresponding to Fig. 3”) should be replaced by a new Fig. 7 (below and in the attachment) with caption “**Fig. 7 Relationship between** $\boldsymbol{\ln\left(\frac{\varphi}{T_2^2}\right)}$ **and** $\boldsymbol{{}^{1}/{T_m}}$ **corresponding to Fig. 3 (Corrected)**”.

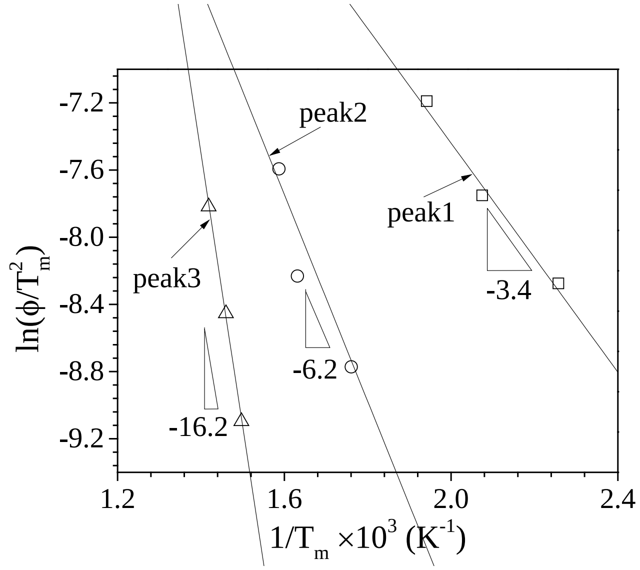

Fig. 7 Relationship between $\ln\left(\frac{\varphi}{T_m^2}\right)$ and $1/T_m$ corresponding to Fig. 3 (**Corrected**).

3. In page 227, “Table 5 Estimated trap site coverage and the amount of hydrogen at each trap site”) should be replaced by a new Table 5 (below and in the attachment) with **caption “Table 5 Estimated trap site coverage and the amount of hydrogen at each trap site (Corrected).”**

Table 5 Estimated trap site coverage and the amount of hydrogen at each trap site (**Corrected**).

Material	**Trap sites**	**Trap density** N_T **(sites/cm^3)**	**Trapped hydrogen** C_T **(atoms H/cm^3)**	**Trap occupancy** $\theta_T=C_T/N_T$
HH	Interstitial	$6.03\times10^{22}=N_L$	$1.28\times10^{13}=C_L$	$2.12\times10^{-10}=\theta_L$
	Solute Mg atom	1.68×10^{21}	3.84×10^{12}	2.29×10^{-9}
	Vacancy	2.71×10^{11}	4.98×10^{6}	1.84×10^{-5}
	Dislocation	3.55×10^{18}	5.45×10^{17}	0.153
	Grain boundary	7.76×10^{17}	2.86×10^{14}	3.68×10^{-4}
	Micropores	-	2.10×10^{17}	-
MH	Interstitial	$6.03\times10^{22}=N_L$	$2.47\times10^{12}=C_L$	$4.09\times10^{-11}=\theta_L$
	Solute Mg atom	1.68×10^{21}	7.42×10^{11}	4.43×10^{-10}
	Vacancy	2.71×10^{11}	9.62×10^{5}	3.55×10^{-6}
	Dislocation	3.34×10^{18}	1.13×10^{17}	0.034
	Grain boundary	4.38×10^{17}	3.12×10^{13}	7.11×10^{-5}
	Micropores	-	1.19×10^{17}	-
LH	Interstitial	$6.03\times10^{22}=N_L$	$1.19\times10^{12}=C_L$	$1.98\times10^{-11}=\theta_L$
	Solute Mg atom	1.68×10^{21}	3.59×10^{11}	2.14×10^{-10}
	Vacancy	2.71×10^{11}	4.65×10^{5}	1.72×10^{-6}
	Dislocation	3.50×10^{18}	5.81×10^{16}	0.017
	Grain boundary	5.35×10^{17}	1.84×10^{13}	3.44×10^{-5}
	Micropores	-	3.19×10^{16}	-

4. Page 224, Paragraph 2, Line 5 to Line 7, sentences “The desorption energy for the corresponding trapping states are 11.4, 17.9, and 31.7 kJ/mol for the vacancy, dislocation and micropores, respectively.” should be corrected as:

The desorption energy for the corresponding trapping states are 27.7, 50.1, and 131.7 kJ/mol for the vacancy, dislocation and micropores, respectively.

5. In page 226, Section 3.4, Paragraph 2, Line 3 to Line 5, sentences “E_b values for the vacancy and dislocation is taken as 11.4 kJmol^{-1} and 17.9 kJmol^{-1}, respectively. Trap site occupancy and the concentration of hydrogen for each trap site are listed in Table 5. It is worth noting that the trap site occupancy is high for grain boundaries ranging from 0.099 to 0.606. It is interesting to note that grain boundaries are the major trap sites in material LH and material HH, higher than the micropores by a factor of 1.66 and 2.24 for material LH and material HH, respectively. In contrast, micropores is the major trap sites in material MH, higher than grain boundaries by a factor of 1.20.”

should be corrected as:

“E_b values for the vacancy and dislocation is taken as 22.7 kJmol^{-1} and 50.1 kJmol^{-1}, respectively. Trap site occupancy and the concentration of hydrogen for each trap site are listed in Table 5. It is worth noting that the trap site occupancy is high for dislocations ranging from 0.017 to 0.153. It is interesting to note that dislocations are the major trap sites in material LH and material HH, higher than the micropores by a factor of 1.80 and 2.60 for material LH and material HH, respectively. In contrast, micropores is the major trap sites in material MH.”.

6. In page 227, Section 4, Paragraph 3, sentences "It was also observed that the trap site occupancy for grain boundary is high ranging from 0.099 to 0.606 (Table 5). Moreover, desorption energy of hydrogen for dislocation (17.9 kJ mol^{-1}) is lower than that of grain boundary (35 kJ mol^{-1}). When moving dislocations meet grain boundaries, hydrogen will be deposited at grain boundaries. Therefore, the increased hydrogen concentration at grain boundaries enhanced the tendency for intergranular fracture [23-24]. However, intergranular fracture mode is dominant only when a very high concentration of hydrogen is available, otherwise, the fracture mode would be transgranular [25]." should be corrected as

"**It was also observed that the trap site occupancy for dislocation is high ranging from 0.017 to 0.153 (Table 5). This increased hydrogen concentration enhanced the tendency for intergranular fracture [23-24]. However, intergranular fracture mode is dominant only when a very high concentration of hydrogen is available, otherwise, the fracture mode would be transgranular [25].**"

7. In page 228, Section 5, "In contrast to this, the absolute amount of hydrogen trapped within grain boundaries in 7XXX alloys with low and high hydrogen content is about 1.66 to 2.24 orders of magnitude higher than micropores. It has also been clarified that the rate of trap site occupancy in grain boundaries is high compared to dislocations and vacancies. Such high hydrogen coverage at grain boundaries indicates that the hydrogen assisted fracture could be intergranular." should be corrected as:

"In contrast to this, the absolute amount of hydrogen trapped within dislocations in 7XXX alloys with low and high hydrogen content is about 1.80 to 2.60 orders of magnitude higher

than micropores. It has also been clarified that the rate of trap site occupancy in dislocations is high compared to grain boundaries and vacancies".

We sincerely apologize for the inconvenience caused.

References

[1] G.M. Pressouyre, Metall. Trans. A 10 (1979) 1571-1573.

[2] G.M. Pressouyre, I M Bernsteine, Acta Metall. 27 (1979) 89-100.

[3] G.M. Pressouyre, Acta Metall. 28 (1980) 895-911.

[4] T. Warner. Materials Science Forum 519-521 (2006), 1271-1278.

[5] G.M. Ludtka, D.E. Laughlin, Metall. Trans. A 13 (1982), 411-425

[6] Z. Chen, Y. Mo, Z. Nie, Metall Mater Trans A 44 (2013), 3910-3920.

[7] T. Marlaud, A. Deschamps, F. Bleyk, W. Lefebvre, B. Baroux, Acta Mater. 58 (2010), 248-260.

[8] D.A. Hardwick, A.W. Thompson, I.M Bernstein, Metall Trans A 14 (1983), 2517-2526.

[9] D.A. Hardwick, A.W. Thompson, I.M Bernstein, Corros Sci 28 (1988), 1127-1137

[10] H. She, W. Chu, D. Shu, J. Wang, B. Sun, Trans Nonferrous Met. Soc. China 24 (2014), 2307-2313.

[11] H. Yoshida, T. Uno, Y. Baba, Journal of Japan Institute of Light Metals 34(1984), 689-701.

[12] M. Vratnica, J. Curovic, Z. Burzic, Material in Technologije 37 (2003), 133-135.

[13] B.M. Cina, US Patent No. 3, 856, 584 (1974)

[14] B.L. Ou, J. G. Yang, C.K. Yang, Maters. Tans., JIM 41 (2000), 783-789.

[15] D. Wang, D.R. Ni, Z.Y. Mia, Mater. Sci. Eng., A 494 (2008), 360-366.

[16] D.K. Xu, P.A. Rometsch, N. Birbilis, Mater. Sci. Eng. A 534 (2012), 244-252.

[17] J. C. Lin, H.L. Liao, W.D. Jehng, C.H. Chang, S.L. Lee, Corros. Sci. 48 (2006), 3139-3156.

[18] G. Peng, K. Chen, S. Chen, H. Fang, Mater. Sci. Eng. A 528 (2011), 4014-4018.

[19] S. Chen, K. Chen, P. Dong, S. Ye, L. Hung, Trans Nonferrous Met. Soc. China 24 (2014), 2320-2325.

[20] M.F. Ibrahim, A.M. Samuel, F.H. Samuel, Mater. Des. 57 (2014), 342-350

[21] S.W. Smith, J.R. Scally, Metall. Mater. Trans A 31A (2003)179-183.

[22] H. Saitoh, Y. Iijima, K. Hirano, J. Mater. Sci. 29 (1994) 5739-5744.

[23] N.J.H. Holroyd, D Hardie, Corros Sci. 21 (1981) 129-144.

[24] D. Nguyen, A.W. Thompson, I. M. Bernstein, Acta Mater. 35 (1987) 2417-2425.

[25] J. Albrecht, I. M. Bernstein, A. W. Thompson, Metall. Trans. A 13 (1982) 811-820.

[26] D. A. Hardwick, A. W. Thompson, I. M. Bernstein, Corros. Sci. 28 (1988) 1127-1137.

[27] C.D.S. Truck, Metall. Trans. A 16 (1985) 1503-1514.

[28] D. Hardie, N.J.H. Holroyd, R.N. Parkins, Mater. Sci. 13 (1979) 603-610.

[29] E.I. Meletis, W. Huang, Mater. Sci. Eng., A 148 (1991) 197-209.

[30] H. Kamoutsi, G.N. Haidemenopoulos, V. Bontozoglou, S. Pantelekis, Corros. Sci. 48 (2006) 1209-1224.

[31] G.A. Young, J.R. Scully, Acta Mater. 46 (1998) 6337-6344.

[32] T. Izumi, G. Itoh, Mater. Trans., JIM 52 (2011) 130-134.

[33] L. Qian, H Toda, K Uesugi, M Kobayashi, T Kobayashi, Phys. Rev. Lett. 100 (2000), 115505

[34] H. Toda, S. Yamamoto, M. Kobayashi, K. Uesugi, H. Zhang, Acta Mater 56 (2008), 6027-6039

[35] L. Qian, H. Toda, K. Uesugi, T. Kobayashi, T. Ohgaki, M. Kobayashi, Appl. Phys. Lett. 87 (2005), 241907.

[36] W.E. Lorensen, H.E. Cline, Computer graphics (ACM) 21 (1987), 163-169.

[37] H.E. Kissinger, Anal Chem, 29 (1957) 1702-1706.

[38] T. Ungár, A. Borbély, Appl. Phys. Lett. 69 (1996) 3173-3175.

[39] W. Woo, T. Ungár, Z. Feng, E. Kenik, B. Clausen, Metall. Mater. Trans. A 41 (2010) 1210-1216.

[40] T. Ungár, G. Tichy, Phys Stat Sol A, 171 (1999) 425-433.

[41] T. Ungár, J. Gubicza, R. Ribárik, A. Borbély, Appl Cryst, 34 (2001) 298-310.

[42] H. Toda, T. Hidaka, M. Kobayashi, K. Uesugi, A. Takeuchi, K. Horikawa, Acta Mater. 57 (2009) 2277-2290.

[43] P. Novak, R. Yuan, B. P. Somerday, P. Sofronis, R. O. Ritchie, J. Mech. Phys. Solids 58 (2010) 206-226.

[44] W.D. Callister Jr., D.G. Rethvoisch, Materials Science and Engineering: An Introduction, 8th Edition, John Wiley & Sons, Inc., p92

[45] G. Lu, E. Kaxiras, Phys. Rev. Lett. 94 (2005) 155501-1-155501-4

[46] R.A. Oriani, Acta Mater. 18 (1970) 147-157.

[47] M. Leger, G. R. Piercy, Philos. Mag. A 43 (1981) 377-385.

[48] R.L.S. Thomas, L. I. Daoming, R. P. Gangloff, J. R. Scully, Metall. Mater. Trans. A 33 (2002) 1991-2004.

[49] R. A. Oriani, NACE, Houston TX, (1969) 32-50.

[50] G. M. Bond, I. M. Robertson, H. K. Birbaum, Acta Mater. 35 (1987) 2289-2296.

[51] G. Lu, Q. Zhang, N. Kioussis, E. Kaxiras, Phys. Rev. Lett. 87 (2001) 095501-1-095501-4

[52] M. Iwamoto, Y. Fukai, Mater. Trans., JIM 40 (1999) 606-611.

[53] Y. Tateyama, T. Ohno, Phys Rev B 67 (2003) 174105.

[54] D.A. Mirzaed, A.A. Mirzoev, K. Yu. Okishev, A.V. Verkhovykh, Mol. Phys. 112 (2013) 1745-1754.

[55] H.K. Birnbaum, C. Buckley, F. Zeides, E. Sirois, P. Rozenak, S. Spooner, J.S Lin, J Alloys Compd. 253-254 (1997) 260-264.

[56] Y. Fukai, N. Okuma, Phys. Rev. Lett. 73 (1994) 1640-1643.

[57] Y. Tateyama, T. Ohno, Phys. Rev. B 67 (2003) 174105-1-174105-10.

[58] K. Shimizu, H .Toda, K. Sasaki, K. Uesugi, A. Takeuchi, Mater. Sci. Technol. 2015, October 2-8 2015, Columbus, OH, USA

[59] H. Saitoh, Y. Iijima, K. Hirano, . Mater. Sci. 29 (1994) 5739-5744.

[60] H. Saitoh, Y. Iijima, K. Hirano, J. JILM 36 (1986) 286-291.

[61] Y. Iijima, S. Yoshida, H. Saitoh, H. Tanaka, K. Hirano, J. Mater. Sci. 27 (1992) 5735-5738.

[62] X.Y. Sun, B. Zhang, H.Q. Lin, Y. Zhou, L. Sun, J.Q. Wang, E.-H. Han, W. Ke, Corros. Sci, 79 (2014), 1-4.