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[2] A Study of the Effect of Natural Aging on Some Plastically Deformed Aluminum Alloys using Two Different Techniques

N. A. Kamel[a]

Faculty of Science, Physics Department,
Minia University,
Egypt

[a]nasser_ak_62@yahoo.com

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Abstract

Electrical and mechanical techniques have been performed in order to study the effect of natural aging for up to more than 650 days on wrought (2024, 7075) and cast ($AlSi_{11.35}Mg_{0.23}$, $AlSi_{10.9}Mg_{0.17}Sr_{0.06}$) aluminum alloys, after having been deformed at room temperature to 25% deformation. The results revealed that, unlike dislocations, point defects were removed from the samples under investigation except for 7075 alloy and this can be attributed to no point defect introduced in this particular sample during the deformation.

1-Introduction

Aluminum alloys have different applications in engineering design area chiefly for their light weight, high strength-to-weight ratio, corrosion resistance, and relatively low cost. They are also utilized for their high electrical and thermal conductivities, ease of fabrication, and ready availability. To study defects properties in the crystal, it is necessary that they are present in sufficiently high concentration. The experimental studies of point defects can in principle be divided into two groups, namely equilibrium experiments and non-equilibrium experiments, i.e. if the investigated defects are in equilibrium with respects to temperature. The equilibrium experiments have the advantage, that they are a study of a particular crystal defect normally present in a concentration large compared to all other defects. The disadvantage of the non-equilibrium experiments is that normally more than one type of defects dominates in the sample at the same time. This make the interpretation of the experimental results very complicated. The most commonly used methods in the non-equilibrium experiments are [1]: 1) *quenching* of samples from high temperatures, i.e. Freezing of the equilibrium concentration of defects attained at this high temperature 2) *radiation damage* of metals and alloys caused by irradiation with electrons, ions or neutrons with high energy 3) *plastic deformation*, which can be performed in ways such as rolling pressing and stretching.

2-Experimental Measurements

In the present studies, the samples under investigation have the chemical composition limits shown in table (1)

Table 1
Chemical Composition Limits of the Samples under investigation

Alloy	Si	Fe	Cu	Mn	Mg	Zn	Ti	Ni	P	Cr	Sb	Sr
$AlSi_{11.35}Mg_{0.35}$	11.35	0.15	0.05	0.05	0.235	0.05	0.125	0.05	0.002	-	0.002	0.002
$AlSi_{10.9}Mg_{0.17}Sr_{0.06}$	10.9	0.14	00.01	0.02	0.17	0.04	0.10	0.02	-	-	-	0.06
7075	0.2	0.25	1.6	0.15	2.5	5.6	0.1	-	-	0.23	-	-
2024	0.5	0.5	4.35	0.6	1.5	0.25	-	-	-	0.1	-	-

These samples were cleaned by electropolishing in a solution of 75% ethanol and 25% nitric acid using Struers equipment (Lectrupol-5). All of the samples were rinsed in pure acetone and in distilled water and dried. The samples were annealed for 12h at 673K, and then plastically deformed at room temperature, using an hydraulic press, to a thickness reduction of 25% with respect to the original dimension.

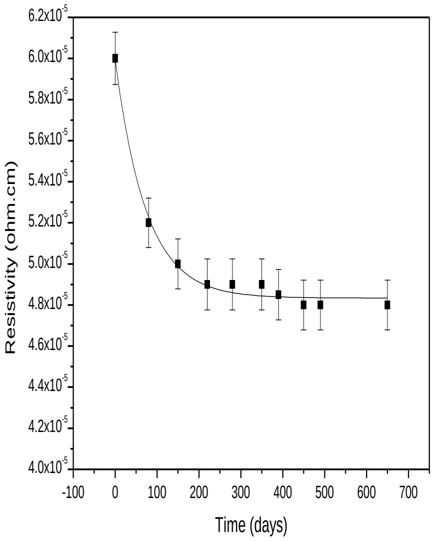

Figure 1
Resistivity as a function of aging time in $AlSi_{11.35}Mg_{0.23}$

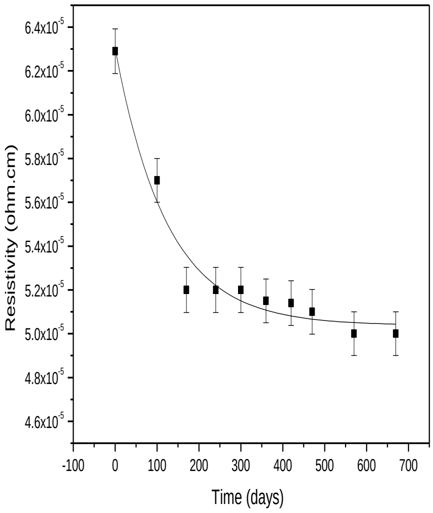

Figure 2
Resistivity as a function of aging time in $AlSi_{10.9}Mg_{0.17}Sr_{0.06}$

2.1 Electrical Measurements

The electrical resistivity, ρ, of the samples was measured by the two-point probe method. The electrodes are brought into contact with the sample surface. A known current is passed through the electrodes, while the voltage reading is made between the surfaces of the sample. The potential difference, V and current, I, were determined using a digital multimeter. The electrical resistivity, ρ, of the samples was calculated according to [2-10]:

$$\rho = R_s\, d$$

where d is the thickness of the sample and R_s is the sheet resistance of the sample, which is given by:

$$R_s = V/I$$

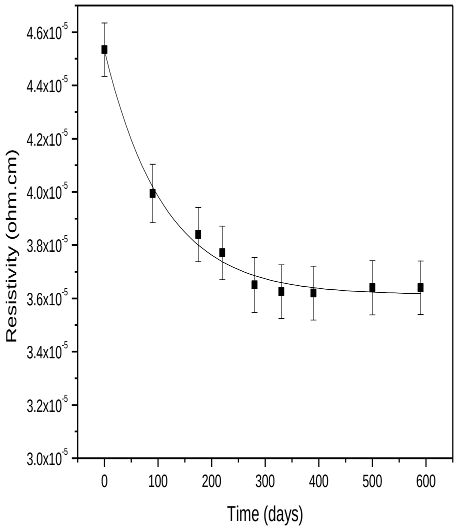

Figure3
Resistivity as a function of aging time in 2024

2.2-Mechanical Techniques

The Vickers hardness test uses a square base diamond pyramid as the indenter. The included angle between the opposite faces of the pyramid is 136^o. The Vickers hardness tester operates on the same basic principle as the Brinell tester, the numbers being expressed in the terms of load and the area of the impression. As a result of the indenter's shape, the impression on the surface of the specimen will be square. The length of the diagonal of the square is measured through a microscope fitted with an ocular micrometer that contains movable knife-edge. The Vickers hardness number is calculated by the formula [11-13]:

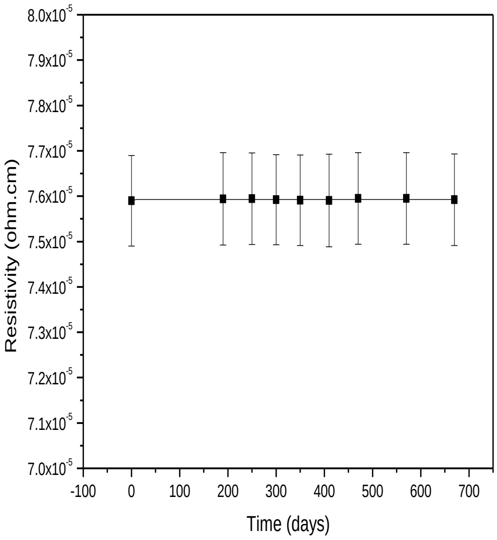

Figure 4
Resistivity as a function of aging time in 7075

$$HV = \frac{1.854xL}{d^2} kg/mm^2$$

where L is the applied load in kg and d is the average diagonal length of the indentation in mm.

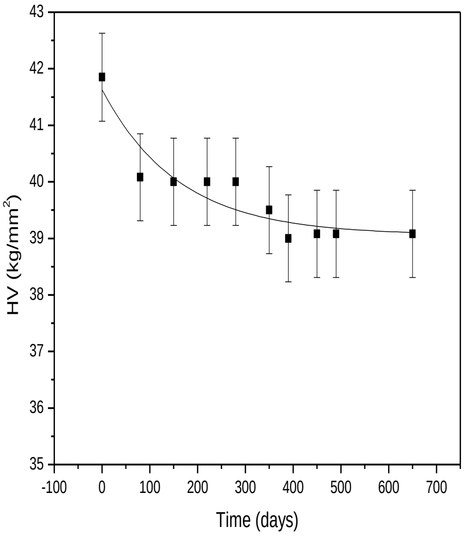

Figure 5
Vickers number as a function of aging time in $AlSi_{11.35}Mg_{0.23}$

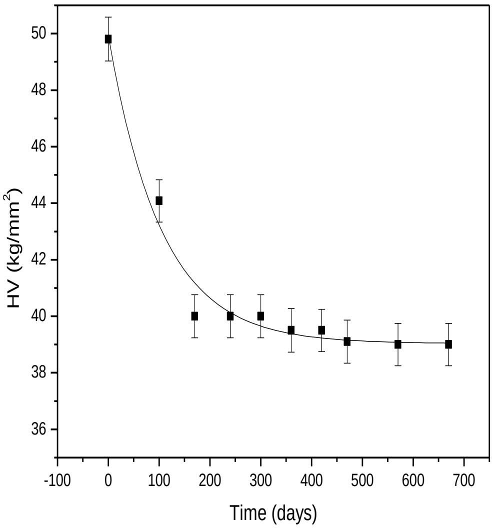

Figure 6
Vickers number as a function of aging time in $AlSi_{10.9}Mg_{0.17}Sr_{0.06}$

3-Results and Discussion

3.1-Electrical Measurement

Electrical and mechanical techniques have been used to study the effect of natural aging for times ranging up to 650 days on wrought (2024,7075) and cast ($AlSi_{11.35}Mg_{0.23}$, $AlSi_{10.9}Mg_{0.17}Sr_{0.06}$) aluminum alloys after being deformed at room temperature to 25% deformation. The effect of natural aging on plastically deformed of these samples were studied by using positron annihilation lifetime technique [14]. From these measurements, it was observed that natural aging could affect only the point defect range. Figure 1 represents the change in resistivity as a function of aging times for the $AlSi_{11.35}Mg_{0.23}$ sample. From figure 1 it is clear that there is a decay in the resistivity. This decay can be attributed to only the point defect (vacancy) was removed from the sample. Figure 2 represents the change in resistivity as a function of aging times for the $AlSi_{10.9}Mg_{0.17}Sr_{0.06}$ sample. From figure 2 it is clear that there is a decay in the resistivity. This decay can be attributed to only the point defect (vacancy) was removed from the sample. Figure 3 represents the change in resistivity as a function of aging times for 2024 sample. From figure 3 it is clear that there is a decay in the resistivity. This decay can be attributed to only the point defect (vacancy) was removed from the sample. Figure 4 represents the change in resistivity as a function of aging times for 7075 sample. From figure 4 it is clear that there is no real change the resistivity and this can be attributed to there is no point defect formation when deforming the sample. From figures (1-4) it is clear that similar behaviour as obtained by positron annihilation technique [14].

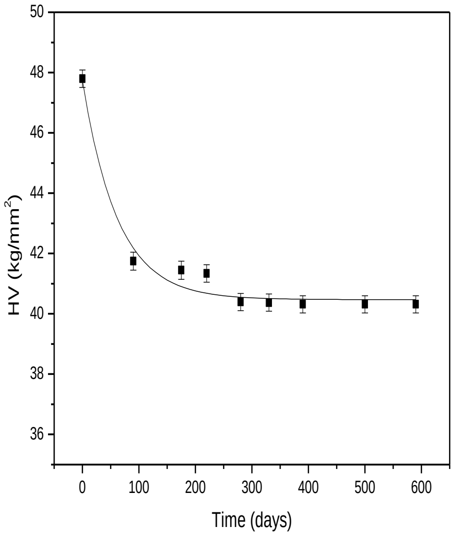

Figure 7
Vickers number as a function of aging time in 2024

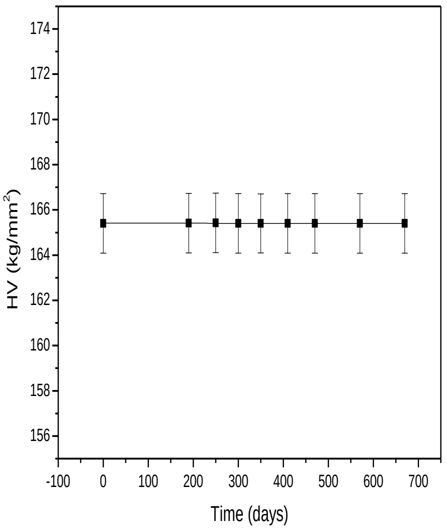

Figure 8
Vickers number as a function of aging time in 7075.

3.2-Mechanical Technique

Figures (5-8) shows the variation of Vickers hardness number as a function of aging time. From figures (5-8) it is clear that similar behaviour as observed by resistivity measurement. Also, similar behaviour obtained by psitron annihilation technique [14].

Conclusion

The effect of aging time on deformed wrought and cast alloys could be recognized upon naturally aging for up to 650 days. There was no real change in the 7075 sample, where no point defect (vacancy) was formed during deformation. But in cast and 2024 alloy, there is a change in rsistivity and Vickers hardness number related to aging time; due to the formation of point defects (vacancies) upon deforming these materials. It is clear that, after 650 days of natural aging, the linear defects remained in the latter material, but the point defects were removed.

References

[1] B. Henderson, *Defects in Crystalline Solids*, 1972

[2] L J Van der Pauw, Philips Research Reports, **13** (1958) 1.

[3] A A Ramadan, R D Gould and A Ashour, Thin Solid Films, **239** (1994) 272.

[4] A Ashour,E Badawi and N Z El-Sayed, Surface Review and Letters, **13**[1] (2006) 69.

[5] M. Abdel-Rahman, N. A. Kamel, Yahia A. Lotfy, Emad A. Badawi and M. A. Abdel-Rahman, Defect and Diffusion Forum, **278** (2008) 1.

[6] Nasser Abdel-Azeem Kamel and Emad A. Badawi, Wakailak Journal of Materials Science and Engineering, **5** (2011) 400.

[7] Nasser Abdel-Azeem Kamel , Abdulla. A. Refeay and Emad A. Badawi, Journal of Materials Science and Engineering A, **1** (2011) 415.

[8] Nasser Abdel-Azzem Kamel and Yahia A. Lotfy**,** Journal of Materials Science and Engineering A, **1** (2011) 711.

[9] N. A. Kamel, Defect and Diffusion Forum, **329** (2012) 11.

[10] M. A. Abdel-Rahman, N. A. Kamel, Abdullah A. Refeay and Emad A Badawi, Defect and Diffusion Forum, **316-317** (2011) 119.

[11] M.A. Abdel-Rahman, Alaa Al-deen and Emad A. Badawi , Defect and Diffusion Forum, **295-296** (2009) 39.

[12] Dubey P K, Bajpai R and Keller J M, Microsyst. Technol., **14** (2008) 1165.

[13] M. F. Eissa, M. A. Kaid and N. A. Kamel, Journal of Applied Polymer Science, **125**[5], (2012) 3682.

[14] M.A. Abdelrahman, M. Abdel-Rahman, N. A. Kamel, M. S. Abdallah and Emad A Badawi, Defect and Diffusion Forum, **265** (2007) 13.