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THE EFFECT OF HEAT TREATMENT ON THE ELECTRON STRUCTURE OF DILUTE AlMgSi TYPE ALLOYS

L. Kertész, J. Kojnok, and A. Szász
Institute for Solid State Physics
Eötvös University, Hungary

A.S. Sulakov
Institute for Solid State Physics
A.A. Zdanov State University, Leningrad, USSR

The changes of the electron density of states of dilute AlMgSi alloys is investigated by soft X-ray Emission Spectroscopy /SXES/ method. The states of the alloy was also measured by differential thermoanalysis /DTA/.

The AlMgSi alloys have been investigated by a number of people and by different methods[1]. It is known that directly after quenching[2] and as the temperature increases, a transformation process takes place, after which a medium temperature G.P. zone and an Si separation can be observed, and later on the solution of this Si takes place at medium temperatures from 480 K to 680 K. At higher temperatures a separation, after which the repeated solution of all the Mg and Si can be observed, from temperatures between 680 K and 800 K in solid phase.

In our present work our purpose was to perform measurements which give direct information concerning the effects influencing the electron structure of the individual processes which take place in the alloys.

We performed the tests on the alloys with the help of soft X-ray emission spectroscopy /SXES/ and the differential thermoanalysis /DTA/.

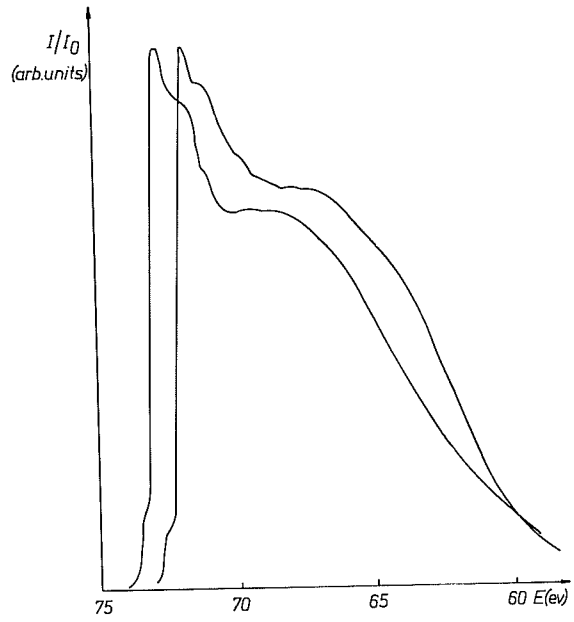

Fig.1 : The SXES plots of the pure Al /99,99 %/ /curve a/ and of AlMgSi alloy /curve b/ measured immediately after the quenching.

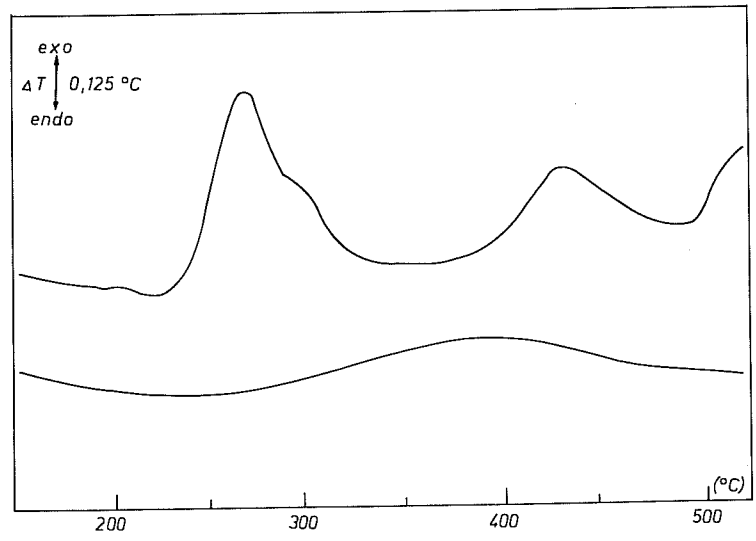

Fig.2 : The DTA curve of AlMgSi alloy measured immediately after the quenching.

Fig.3

Fig.4

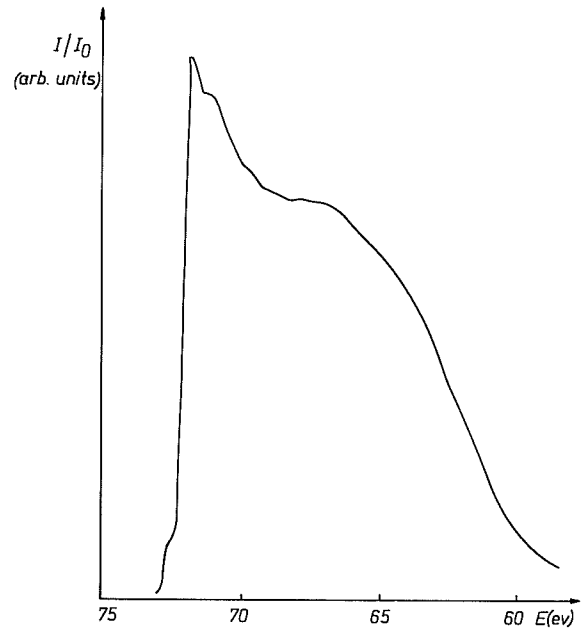

Fig.3 : The SXES curve of AlMgSi annealed for 6 hours at 443 K.

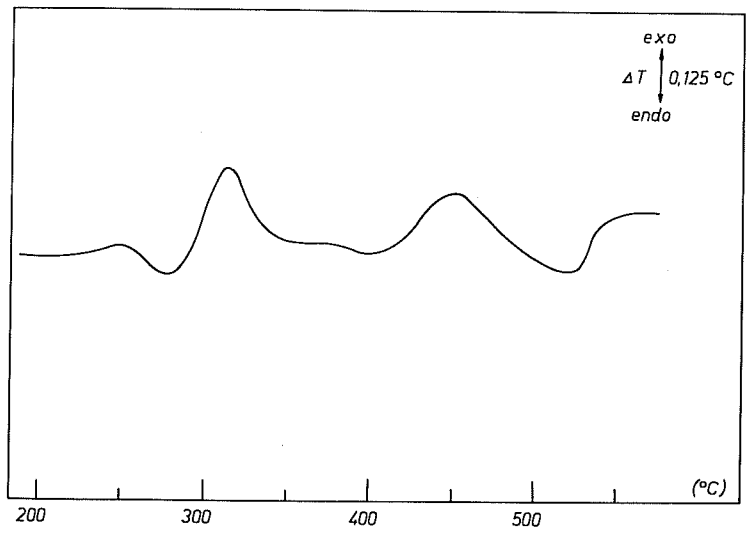

Fig.4 : The DTA curve of the alloy annealed for 6 hours at 443 K.

We obtained the basis information with SXES from the surface layer of a thickness 200 nm.

The main point of the measurement is that it gives direct information about the electron density of states[3]. The concentration of the alloying elements is relatively low, so we paid attention first of all to the energy range characteristic of the Al matrix, to the Al $L_{2,3}$ level.

We performed the SXES tests with the help of the type RSM 500 device, the detailed description of which was given by Lukirszkij and Britov[4]. The DTA tests were given with the help of the DTA equipment[5].

The composition of the tested specimens was the following: Mg 0,58 wt % /0,65 at %/, Si 0,35 wt % /0,34 at %/ Fe 0,14 wt %/ 0,068 at %/, Cu 0,01 wt %, Ti 0,03 wt %.

We achieved the different physical conditions in the alloys with a two-stage heat treatment. In the first stage each specimen received resolving heat treatment for 45 minutes at 800 K temperature, after this it was quenched in water at room temperature,which was followed by either immediate testing, or the specimen was subjected to another heat treatment.

On the first figure we show the SXES plot of pure Al /99,99 %/ and of AlMgSi /curve / alloy taken of the specimen measured immediately after the resolving heat treatment and quenching. The most striking observation is that the Fermi level has shifted by the value of 0,8 eV $\pm$ 0,3 eV, at the time increases the density of the lower states from 67 eV to 70 eV. The fine structure of the curve, that is the local maximum points are more blurred, that is not every point shows up.

On figure 2 we illustrate the DTA curve of the alloy of the same state. On the curve up to point M, to about 480 K, there is a prolonged process with inherent heat rejection, which is followed by the M heat absorption process, and then at medium temperatures between 520 K and 590 K two large superimposed exotherm processes /peaks marked by N_1 and N_2/ can be seen, among others. We can easily distinguish the formation of the low temperature G.P. zone, the medium temperature zones and the Si separation on the given temperature points.

According to the evidence of the DTA measurements, the specimen tested by SXES was an optimally supersaturated metastable solution.

Fig.5 : The

Fig.6 : The

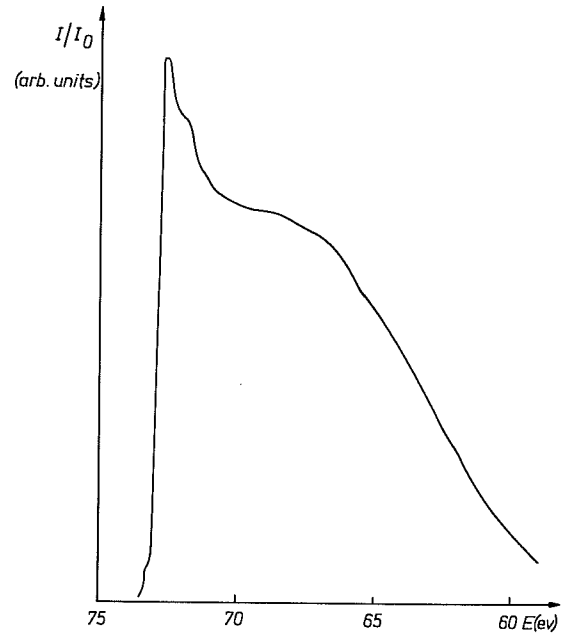

Fig.5 : The SXES curve of AlMgSi annealed for 40 min at 573 K.

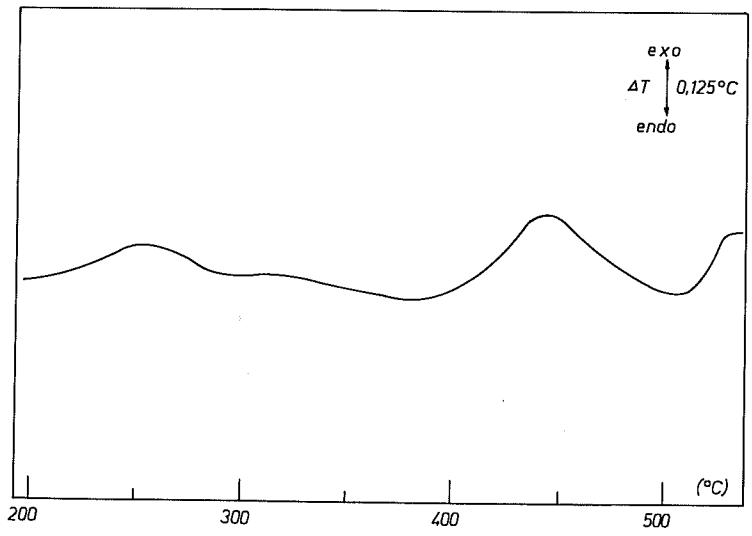

Fig.6 : The DTA curve of AlMgSi annealed for 40 min at 573 K.

On figure 3 we plotted the SXES curve of the alloy annealed for 6 hours at 443 K temperature. The Fermi level corresponds to that of the pure Al. The fine structure characteristic of the Al curve can be approximately found in this measurement too and this indicates that the band structure and density of state of the Al matrix are not essentially affected by the alloying elements put into Al.

On figure 4, on the DTA curve of this same state, the low temperature exotherm and the changes indicated by M and N_1 practically disappeared, a large scale medium temperature zone formation took place /around 540 K/. This process partially decreased the alloying content of the solution and this adequately coincides with the results of the emission measurements also.

The SXES curve taken of the sample annealed for 40 minutes at 573 K, after the resolving heat treatment and quenching is shown on figure 5. The Fermi level /72,8 eV/ corresponds to that of the pure Al, within the measuring accuracy. An essential change can be seen in the slight decrease of the relative peak height connected to the K symmetry point.

On figure 6 we plotted the DTA curve of this same state of alloy. Comparing this with the curve plotted of the alloy having the previous state, it can be ascertained that up to 590 K practically no effects show up. These conditions indicate that the Mg and Si content of the Al matrix is starved to a great extent.

In comparison to the previous state further significant Si separation took place and in consequence the electron density of state resulting in peak K also decreased.

From the measurements performed so far we can ascertain that the different states, sections of the processes between the solute metastable state and the state approaching equilibrium, are reflected in the electron structure of the alloy.

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