Electrical and galvanomagnetic properties of $AuAl_2$+6%Cu intermetallic compounds at low temperatures

2012 J. Phys.: Conf. Ser. 400 042044

(http://iopscience.iop.org/1742-6596/400/4/042044)

Journal of Physics: Conference Series **400** (2012) 042044 doi:10.1088/1742-6596/400/4/042044

Electrical and galvanomagnetic properties of $AuAl_2$+6%Cu intermetallic compounds at low temperatures

V V Marchenkov[1], A Yu Volkov[1], O N Kapitonova[2], H W Weber[3]

[1] Institute of Metal Physics, 620990 Ekaterinburg, Russia

[2] Ural Federal University, 620000 Ekaterinburg, Russia

[3] Atominstitut, Vienna University of Technology, 1020 Vienna, Austria

E-mail: march@imp.uran.ru

Abstract. The $AuAl_2$ intermetallic compounds are of substantial interest in view of their application potential. The investigated intermetallics $AuAl_2$+6%Cu were prepared from fine powders of $AuAl_2$ and Cu by vacuum sputtering on a glass substrate and consisted of films with a thickness of about one micrometer. The films were annealed. The temperature and field dependence of the electroresistivity, the magnetoresistivity and the Hall effect of $AuAl_2$+6%Cu films were measured in the temperature interval from 4.2 to 100 K and at magnetic fields of up to 15 T. We demonstrate that the temperature dependence of the electroresistivity has a minimum at T = 20 K and a metallic behavior above this temperature. The magnetoresistivity is very small (less then 1%), positive at low temperatures and negative above 12 K. The Hall coefficient is positive, which corresponds to the holes in a one zone model with a charge carrier concentration of about $1.6 \cdot 10^{20}$ cm^{-3}.

1. Introduction

The interest in $AuAl_2$ stems from the possibility of using this intermetallic compound as a sensor material, a spectrally sensitive solar radiation absorber, a precursor for the fabrication of gold catalysts with a tailored pore size, etc. [1]. The salient feature of this compound is its very unusual bright purple color, which is sometimes referred to as purple glory [1, 2]. This unusual deep color has attracted the attention of designers and jewelers, all the more because the gold content of this intermetallic compound is close to that of 18 karat gold.

Since the articles devoted to studying this intermetallic compound are scarce, information about its physical properties is highly desirable. The aim of this paper is to study the electrical and galvanomagnetic properties of $AuAl_2$+6%Cu compounds at low temperatures.

2. Experimental

Fine powders of $AuAl_2$ were prepared through mechanical alloying by milling a mixture of pure Au and Al metals in a planetary ball mill [3]. Six atomic percent of Cu were added to the $AuAl_2$ powder, since the content of $AuAl_2$+6%Cu exactly corresponds to a gold content of 18 karat. The investigated intermetallics were prepared from fine powders of $AuAl_2$+6%Cu by vacuum sputtering onto a glass substrate and consisted of films with a thickness of about 1 micrometer. Then the films were annealed.

The temperature and field dependence of the electro- and magnetoresistivity and the Hall effect of these films were measured in the temperature interval from 4.2 to 100 K and at magnetic fields of up to 15 T.

3. Results

Fig. 1 shows the temperature dependence of the electroresistivity of the intermetallic compound $AuAl_2$+6%Cu before and after annealing. The electroresistivity before annealing is quite large, i.e. more than 330 μOhm·cm, and shows semiconducting behavior. ρ(T) decreases with increasing temperature. Annealing leads to decreasing electroresistivity ρ by almost 3.5 times and at T > 20 K the resistivity turns to metallic behavior, i.e. ρ increases with increasing temperature (Fig. 1). Apparently, such big changes are caused by intermetallic ordering upon annealing.

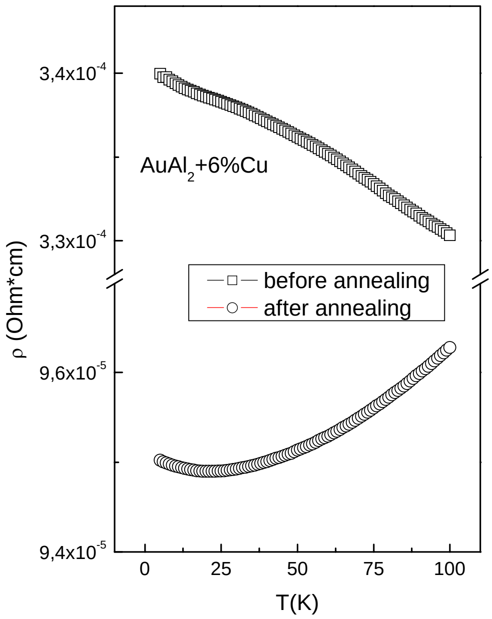

Figure 1. Temperature dependence of the electroresistivity of the $AuAl_2$+6%Cu compound before and after annealing.

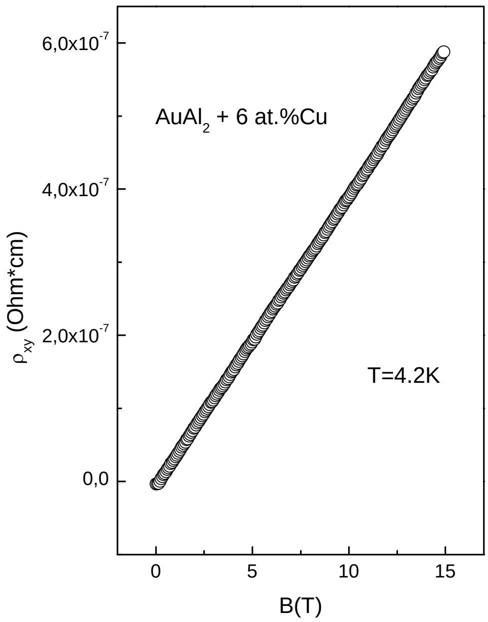

Figure 2. Filed dependence of the Hall resistivity at T=4.2 K of the $AuAl_2$+6%Cu compound after annealing.

It is interesting to examine the physical reasons for the minimum in ρ(T) at T ≈ 20 K (Fig. 1). One possibility is the Kondo effect [4], i.e. the presence of a small amount of ferromagnetic Fe, Ni, etc. atoms in the intermetallic $AuAl_2$+6%Cu compound, which may be due to the mechanical alloying. The fact that the magnetoresistance of the annealed intermetallic is negative and very small is also in favor of this assumption. However, to clarify this behavior of ρ(T), additional experiments are needed and planed for the near future.

The Hall effect of the annealed $AuAl_2$+6%Cu was also studied and the sign and the concentration of charge carriers were obtained using a one band model [5]. Fig. 2 shows the field dependence of the Hall resistivity $\rho_{xy}(B)$ at T = 4.2 K. ρ_{xy} is positive and increases linearly with magnetic field, which is typical for a nonmagnetic metal. Then the temperature dependence of the Hall coefficient $R_H(T)$ was studied in a field of 10 T and the concentration n of the charge carriers obtained from $n = 1/R_H \cdot e$, where e is the electron charge.

Fig. 3 shows the temperature dependence of the charge carrier concentration n(T). n is positive in the entire temperature interval. In a one band model this means that the current carriers are holes. n has a weak non-monotonic dependence, i.e. n decreases with temperature up to approximately 25 K and then increases with T. Typical values of n are about $1.6 \cdot 10^{20}$ cm^{-3}.

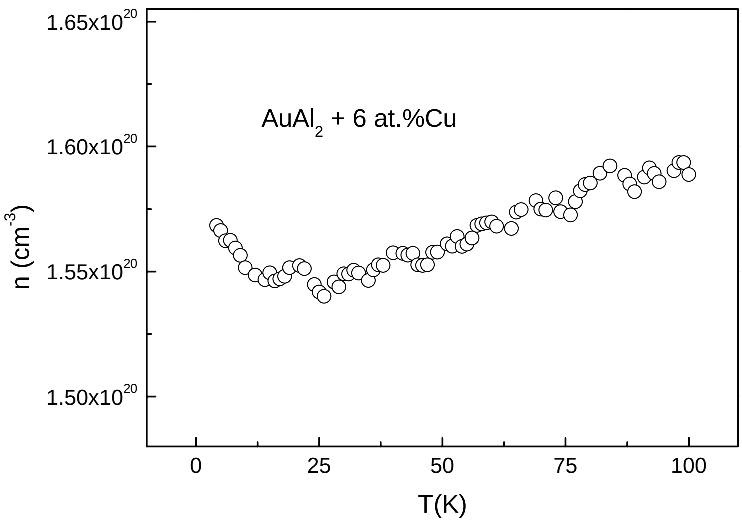

Figure 2. Temperature dependence of the charge carrier concentration of $AuAl_2$+6%Cu.

4. Conclusions

We demonstrate that the intermetallic compound $AuAl_2$+6%Cu is a "bad" metal at low temperatures with an electoresistivity of about 100 μOhm·cm and with a concentration of charge carriers, which are holes, of about $1.6 \cdot 10^{20}$ cm^{-3}.

5. Acknowledgements

This work was partly supported by the Austrian Academy of Sciences and by the UB of RAS (project No 12-U-2-1004).

References

[1] C. Cretu, and E. van der Lingen. Gold Technol. **30**, 31 (2000).
[2] S. Supansomboon, A. Maaroof, and M.B. Cortie. Gold Bull. **41**, 296 (2008).
[3] A.Yu. Volkov, M.A. Uimin, A.A. Mysik et al. Inorganic Materials **47**, 465 (2011).
[4] J. Kondo. Progress of Theoretical Physics **32**, 37 (1964).
[5] I.M. Lifshitz, M.Ya. Azbel and M.I. Kaganov. Electron Theory of Metals (Consultants Bureau, New York, 1973).