EFFECT OF Re SUBSTITUTION WITH Mn ON THE ELECTICAL PROPERTIES OF $Al_{71}Pd_{19}Mn_{10-x}Re_x$ SYSTEM

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Abstract: *The interrelation between temperature and electrical resistivity has been investigated for* $Al_{71}Pd_{19}Mn_{10-x}Re_x$ *quasicrystals over a composition range x=0, 0.5, 1, 1.5 and 2at %. By analysing the temperature dependence of the electrical resistivity we can conclude that it is decreasing with increasing temperature in range of 0 to 300K. At the room temperature and low concentration of Re, electrical resistivity has a minim value at 1% at Re. Quasicrystals possess high hardness and tribological properties which can be used to make them not only candidates for new thermoelectric materials but for composite materials with metallic matrix.*

Key words: *quasicrystals, electrical resistivity, annealing, X-ray diffraction*

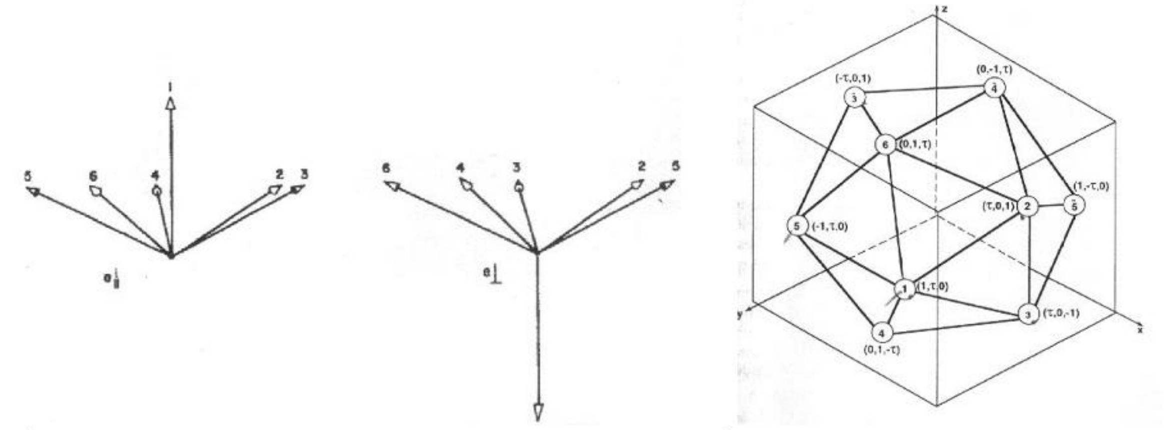
Introduction

First quasicrystal was observed in 1984 by Danny Schechman in an alloy of Al with 14%at Mn using electronical microscopy (JANOT, 1998). Quasicrystals have aperiodic ordered structures which are different from either crystalline or disordered materials.

Quasicrystals are a new type of space filling form of matter. These intermetallic compounds are stable and exhibit a specific long range order together with an orientational order associated with symmetry properties which are forbidden in periodic crystals. The icosahedral AIPdMn system is considered as a model system. For this system. fivefold axes are observed in diffraction patterns obtained using neutron, x-ray, or electron beams. These diffraction data are the experimental basis of the accepted models, which describe the atomic decoration of the quasicrystaline structure (MARCHESINI, 2000).

A striking feature of quasicrystals is that in spite of the fact that they are also nonperiodic in 3D space, their structure can still be characterized by a minimal set of parameters in the six-dimensional superspace, similar to "normal' crystals in 3D real space. This periodic 6D structure can be projected on 3D space to obtain a perfect idealized quasicrystaline structure (Fig 1). Starting from these models, on can obtain not only long range order but also evidence for a high local order with respect to distances and orientations. In particular, this description implies a finite set of local atomic structures around the Mn atoms.

The smaller Mn atoms are surrounded by 12 Al atoms arranged at the corner of icosahedron. The structure is made up of parallel icosahedra attached at their edges. Crystals cannot exhibit the fivefold symmetry of on icosahedron, but a crystal can be constructed by nucleation at a centre cell, followed by outward growth from there. All the space of a nodule cannot be filled out by repeating the basic unit, although the "parallel" part of the specification does give a long range orientation order to the structure.



a) b

Figure1. The icosahedral basis vectors in physical space and pseudospace -a) irrational components (±1,±τ, 0) or permutations of a_i vectors of pseudoicosahedral on axis system -b)

Quasicrystals have some interesting properties, such as a good thermal stability, low friction, corrosion, irradiation and oxidation resistance absorption of sun beams, stoking of hydrogen. Also, possess high hardness and very good tribological properties which can be used to make them not only candidates for new thermoelectric materials but for composites materials with metallic matrix.

Quasicrystals are intermetallic alloys and are very poor electrical conductors. They are nearly insulators with a somewhat well-defined bands gap at the Fermi level

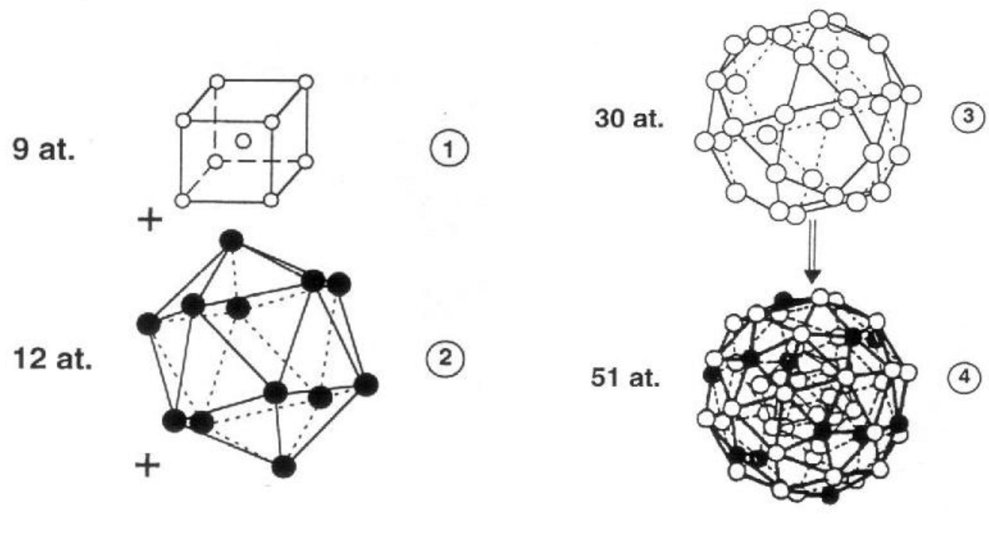


Figure 2. Successive atom shells forming the bridging atom clusters of Mackay pseudo-icosahedra

Quasicrystals possess properties associated with both amorphous materials and crystals. Recently quasicrystals have been investigated for thermoelectrics and show reasonable properties. Electrical properties of quasicrystals have been the subject of great interest since the discovery of quasicrystals. The interest for the high resistivity of quasicrystals has been enhanced in recent years by experiments for high – quality, thermodynamically stabile quasicrystals of Al-(Ru,Fe)-Cu and Al-Pd-Mn systems discovered by Tsai et al (TSAI, 1990).

In this paper, we report the results for Al-Pd-Mn-Re icosahedral quasicrystals, in which some annealing samples show the resistivity values at 3400 μΩcm at room temperature and 5100 μΩcm near 0 K.

Experiment and process analysis

In this study, the electronic transport properties of $Al_{71}Pd_{19}Mn_{10-x}Re_x$ (x=0, 0.5, 1,1.5 and 2at.%) quasicrystals were systematically investigated.

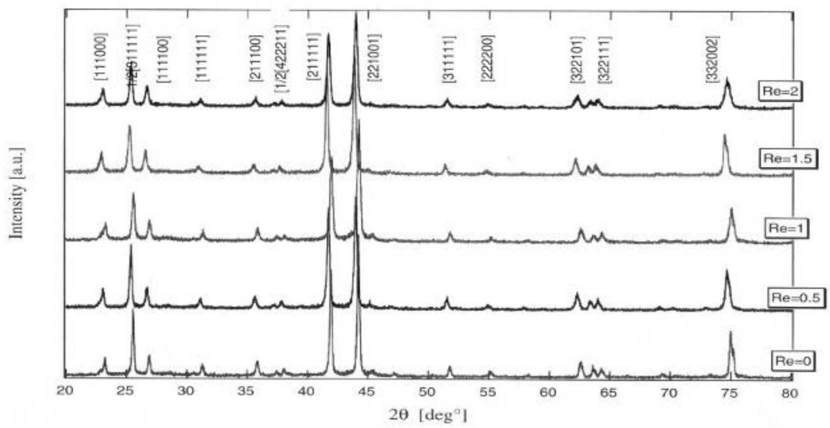


Figure 3. CuK∝ powder diffraction pattern of $Al_{71}Pd_{19}Mn_{10-x}Re_x$

Alloy ingots were prepared with appropriate amounts of pure elements by arc melting in a pressurized Argon atmosphere. Then samples were formed into ribbon-shape by the single roll melt-spinning techniques. The thermal stability of the phases in the quenched ribbons was analysed with the differential scanning calorimeter. The results of these experiments had been used to establish annealing temperatures. Then all samples were introduced in quartz tube in vacuum and annealed at appropriate temperatures in order to improve their quality. Different annealing in the range of 500-750°C was used to improve sample homogeneity.

The phases and the composition of all samples were studied by powder X-ray diffraction with CuK∝ radiation using a RIGAKU diffractometer with high resolution and the energy dispersive X-ray analysis (Fig.3). For indexed diffraction images was used Elser technique (Elser, 1985; BROWN, 2000). Generally after application of annealing the picks are higher that shown us the order of atoms in quasicrystal are bigger. These results were used to determine the lattice constant.

The electrical resistivity of the quasicrystals thus obtained was investigated by increasing the temperature (Fig.4).

Resistivity was measured from 0 to 300K using the standard four-probe technique with gold paint contact. The resistivity is decreasing about 1.5 times if temperature increases.

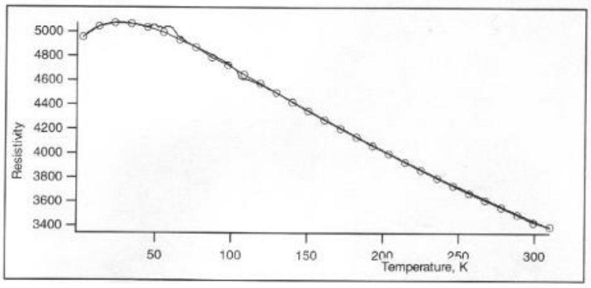


Figure 4. Temperature dependence of resistivity for $Al_{71}Pd_{19}Mn_8Re_2$ annealing 500

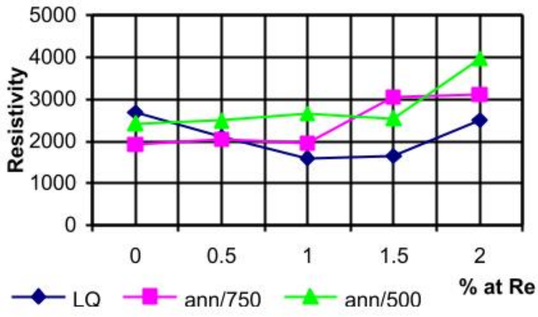


Figure 5. Resistivity dependence of Re concentration at room temperature

The electrical resistivity of every alloy was measured at 300 K using a four-lead probe (TAKEUCHI, 1998). In addition of low concentration of Re, resistivity decreases at about 1%at Re and then it increases (Fig.5).

The obtained values are between 1500 and 4000μΩcm. Generally, after application of annealing the resistivity increases.

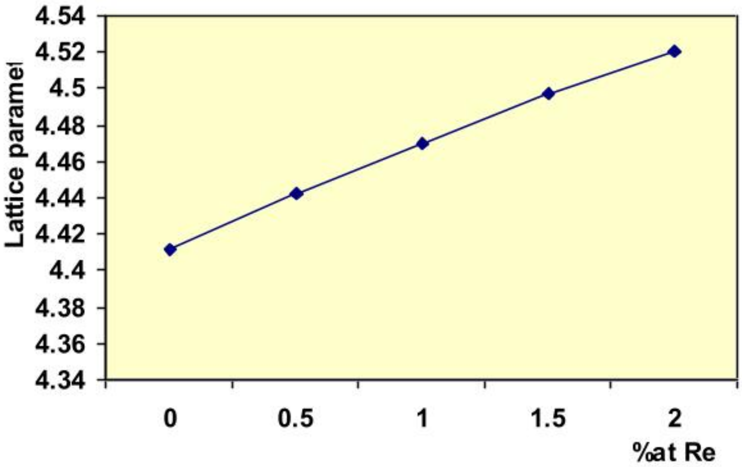


Figure 6. The lattice parameter of the $Al_{71}Pd_{19}Mn_{10-x}Re_x$

With increasing of Re concentration, the quasi-lattice parameters a_R of each alloy was getting increased, reflecting a difference in the atomic size between Re and Mn (Fig 6). The highest variation of quasi-lattice parameter is 1.58 % from a_{Rmax} Conclusion. The quasicrystals of Al-Pd-Mn-Re have potential for thermoelectric applications at elevated temperatures.

The resistivity of Al-Pd-Mn-Re quasicrystals decreases about 1.5 times when temperature increases to 300K.

The effect of Re substitution with Mn on the electrical properties of the Al-Pd-Mn quasicrystal was a decrease of resistivity till 1%at Re and then it increases when the Re contain increases.

Systematically studies of the thermoelectric properties of Al-Pd-Mn-Re quasicrystals should be performed.

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