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Al, Pd Elements Deposited on the Surface of Al-Pd-Mn Quasicrystal

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Al, Pd Elements Deposited on the Surface of Al-Pd-Mn Quasicrystal

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Abstract: Pd element has been deposited on the clean surface of an Al-Pd-Mn quasicrystal by evaporation and using low energy ion scattering (LEIS) technique. The sample was prepared through a combination of sputtering and annealing. Then a Pd monolayer was deposited on the surface and measured the ratio of Al/Pd for clean annealed surface at the room temperature. Drawing the Al/Pd ratio versus time deposition showed a linear behavior, indicating Pd growth is Layer Growth (Frank-Van der-Merwe Growth). Similar experiment for Al has also been done. Results show that growth of Al on the sample is also conform Layer Growth (LG).

Keywords: Deposition; Al-Pd-Mn quasicrystal; Surface; Growth of layer; Low Energy Ion Scattering (LEIS);

1 Introduction

Quasicrystals [1] are fascinating substances that form a family of specific structures with strange physical and mechanical properties as compared to those of metallic alloys. This, on the one hand, is stimulating intensive research to understand the most basic properties of quasicrystals in the frame of a generalized crystallography. On the other hand, these properties open way to technological applications, mostly regarding energy savings [2].
They also show unusual properties such as friability, low surface energy and good cover resistance [3,4], low coefficient of friction, good wear, etc.[3,5]. Quasicrystalline coatings hold significant industrial interest due to their high hardness by the standards of Al alloys. They are also noteworthy in their low coefficients of friction compared with steels and Al alloys [6]. For improving their properties, it is necessary to embed thin layers of different materials on them. It is sometimes necessary to know how to deposit a layer on the quasicrystals so that their surface is covered completely. Therefore, the layer deposition by evaporation is used to embed a layer of the element of interest on the specimen.

There are different methods available for layer deposition such as evaporation, electron beam, ion beam and plasma. What is more important is the type of growth for elements onto layer. The condensation of thin layers occurs in different forms. Growth mechanism of one element onto substrate include: layer growth, island growth and island-layer growth. The first group is layer growth in which the tensile force between substrate atoms and layer is more powerful than that between the layer atoms alone. In this case, each layer is completed and the next layer starts to form. This method is called Frank Vandermerve growth. The second group is island growth in which the tensile force between layer atoms is stronger than that between layer and sub layer atoms. This method is called Velmer-Weber. The third group is island-layer growth called Stransky-Krestanov in which one or some layers are formed and then the islands are completed. To characterize how the layers grow, we can focus on surface energy or surface tension.

This paper presents the results of an experimental study of growth type of deposition of both Al, Pd elements on the Al-Pd-Mn quasicrystal by Low Energy ion scattering (LEIS). LEIS allows the study of the composition and structure of a surface by the detection of low energy ions with energies ranging from 100eV to 10KeV elastically scattered off the surface. The extreme sensitivity to the outermost atomic layer makes it as a unique tool for surface analysis [7]. In this work, we want to embed thin layer of Pd and Al separately on each other and then study the ways to improve the properties of quasicrystal. Characterizations of prepared cover were done by plotting the ratio of two elements versus time of deposition.

2 Material and Methods (Experimental Details)

The experiments were performed in a Leybold-Hereas UHV ion scattering system (base pressure 10-10 mbar) with mono energetic, 2 keV He ions. The scattering geometry chosen for

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these experiments were 30º and 60º for incidence and scattering angles to obtain high yield, respectively. The single grain sample of i-Al-Pd-Mn was grown at the Ames Laboratory by the Bridgman method. The Ames Laboratory group reported the bulk composition of the sample to be Al69.9 Pd20.5Mn9.6.
The surface perpendicular to a 5-fold axis was initially cleaned in vacuum via a number of sputter-anneal cycles, each involving 30 minutes of sputtering with He+ followed by a 45 minutes anneal. The annealing temperature of the first cleaning cycle was 450K and was increased by 50K for each cycle thereafter until a final annealing temperature of 800K was reached. After the cleaning procedure and prior to each experiment, the sample was sputtered using He+ and annealed at 800K. After the cleaning procedure, the surface appears free of oxygen and strong scattering by Al and Pd is observed along with a very small feature attributed to scattering from Mn.

3 Discussions

3.1 Deposition of Pd

First, we clean a sample. After a while, we expose it to Pd radiation. Pd was deposited on the surface of sample by professional evaporator. The time of deposition is between 1.5 to 2 min. Figure 1.shows the Al/Pd rate versus time. This rate decreases with increasing time.
Therefore by increasing the amount of Pd on the surface the Al/Pd ratio started to decrease.
Plotting the Al/Pd ratio versus time, if it is linear, it is concluded that it obeys the layer growth, but if the curvature during declination has non-linear behaviour, it shows that it is a type of island growth.

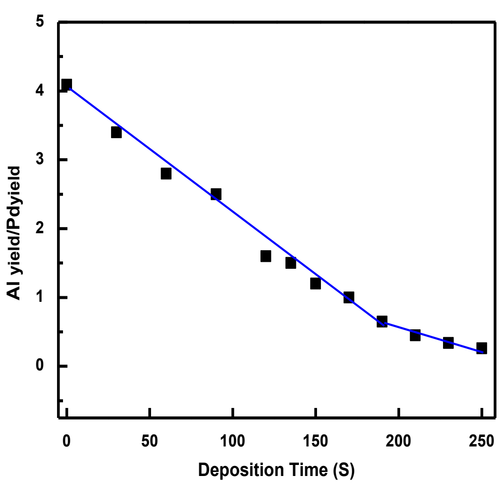

Figure 1. Al/Pd rate versus deposition time

Also, breaking in the plot is caused by two facts:

Firstly, existence of Al count is due to Al atoms in the second layer. In fact, LEIS information is taken from the first layer of Al, and from second and third layers as well and this number is due to the interaction of e with Al atoms in the second and third layers. And secondly, the ratio of Al/Pd count in this time is much less than the count of Al/Pd coming from the second and third layers. Also these counts can be caused by the background or this fact that the energy spectrum cannot take a single value. The reason is that this ratio after a long time (infinitive) goes to zero.

3.2 Al deposition

For a cleaned sample, Al counts are shown in the following table. After a while, it is subjected to Al radiation in 1.5 to 2 min that 1.34 min was the chosen time for rest of the experiments. The condition for deposition of Al on the Al-Pd-Mn quasicrystal is presented in Table 1.

Table 1. Deposition conditions for Al

I(A)	I_e(mA)	V(Kv)	Flux
5.5	50	0.8	3×10^{-7}

First, some pure Al is put in an Alumina container, to be heated by the current related to the element and then Al is evaporated and deposited on the sample.
If Pd/Al ratio is measured, there is a reduction of ratio over the time. The linear or non-linear behaviour of the curve is dependent to the type of growth.
When Pd/Al decreases at equal distances over time, the surface of quasicrystal covered with Al increases and it can be concluded that the type of growth is layered. But if Pd/Al rate reduction does not change uniformly, growth is a type of island.

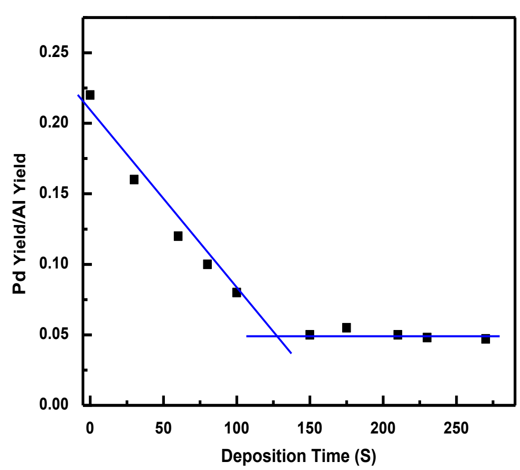

Figure 2. Pd/Al rate versus deposition time

Regarding figure 2, Al deposition on quasicrystal is layered and at point 150 sec there is seen another linear reduction with lower slope not considered in calculations because it is related to the variation of Pd/Al which comes from second and sometimes third layers. Therefore, it takes 150 seconds to have an Al layer on quasicrystal with the conditions of table 1. Finally the time of 120 seconds was considered to be cautious. The results show that growth of Al on the sample is also conform Layer Growth (LG) and also study by Sharma et al [8].

4 Conclusions

According to the obtained results, Al growth on sample is layer by layer. Similar experiments were also done for Pd, showing layer growth as well. Related amounts for Al/Pd ratio decreases was from 4 to 0.7 at 190 s and for Pd/Al ratio was from 0.22 to 0.07 at 100 s which are showing deposited elements obey a layer growth.

The curve turns into another line with a smaller slope than the first one that confirms the deposition follows the layer mechanism. The little value of the ratio amounts in both of the curves come from not calculating the background and from information of the former first layers covered with deposition and the second layer is the former first layer.

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