(2) STRUCTURE OF THE Al-Rh-Cu DECAGONAL QUASICRYSTAL (One-day Symposium on Quasicrystals)(Miscellany)

著者	Li Z., Hiraga K., Yubuta K.
journal or publication title	東北大学素材工学研究所彙報 = Bulletin of the Institute for Advanced Materials Processing, Tohoku University
volume	53
number	1/2
page range	132-133
year	1998-03-27
URL	http://hdl.handle.net/10097/34226

素材工学研究会記事

One-day Symposium on Quasicrystals

(平成9年2月10日
於 東北大学素材工学研究所)

(1) DISLOCATIONS AND PLASTICITY IN QUASICRYSTALS

Forschungszentrum Julich, KFA
K. Urban

The quasicrystalline state of solid matter was discovered in Al-Mn alloys in 1984. For many years quasicrystal research has been dominated by efforts to clarify the nature of the structure of this novel state. Quasilattice defects were treated theoretically but experimental work in this field was limited. In binary alloys such as Al-Mn quasicrystalline phases occur only as metastable states and the samples are polygrained. The structure is intrinsically very defective and the grain sizes rarely reach more than a few tens of micrometers. This situation changed drastically in 1989, when new quasicrystalline phases in ternary alloy systems such as Al-Cu-Fe and Al-Cu-Co, which contain thermodynamically stable quasicrystalline phases, were discovered. Today large single-quasicrystals of icosahedral Al-Pd-Mn can be grown from the melt by the Czochralski technique. The very high structural quality of these materials permits the investigation of defects and intrinsic physical properties. Quasicrystals exhibit properties quite similar to those of silicon when subjected to mechanical load at room temperature. They combine a high Vickers hardness typically between 800 and 1000 with high brittleness. Upon heating, the hardness decreases continuously and, at temperatures above about 600℃, quasicrystals become ductile. There are indications that plastic deformation at room temperature is mediated by a microcrack mechanism. In the following we concentrate on high-temperature deformation between about 680 and 800℃.

(2) STRUCTURE OF THE Al-Rh-Cu DECAGONAL QUASICRYSTAL

Institute for Materials Research,
Tohoku University
Z. Li, K. Hiraga and K. Yubuta

The coexistence of a decagonal quasicrystal and crystalline phases in a conventional solidified $Al_{65}Rh_{20}Cu_{15}$ alloy was early reported in 1989 (Tsai, Inoue, and Masumoto, 1989, *Mater. Trans., JIM*, **30**, 463). The Al-Rh-Cu decagonal quasicrystal has a periodicity of about 0.4 nm along its unique tenfold axis. In the present study, the structure of the Al-Rh-Cu decagonal quasicrystal has been investigated by using a 400 kV electron microscope (JEM-4000EX) with a resolution of 0.17 nm (Li, Hiraga, and Yubuta, 1996, *Phil. Mag. Lett.*, **74**, 247). A HREM image taken with the incident electron beam parallel to the tenfold axis can be interpreted as an aperiodic tiling composed of three kinds of subunits, deformed hexagon, crown and five star. It is shown that the structure of the Al-Rh-Cu decagonal quasicrystal is different from the structures of the Al-Co-Cu and Al-Ni-Co decagonal quascrystals, which were found mainly to be composed of large decagonal subunits. The atomic arrangement in the subunits of the Al-Rh-Cu decagonal quasicrystal has been proposed. A calculated image based on the present model reproduces well the contrast features of the observed image. Quasiperiodic tessellation of the three kinds of subunits generates the two-colour Penrose tiling (Li, Dubois and Kuo, 1994, *Phil.Mag. Lett.*, **69**, 93). A high-dimensional description of the ideal structure of the Al-Rh-Cu decagonal quasicrystal has been proposed (Li,

Hiraga, and Yubuta, 1996, *Physica b*, in preparation).

(3) STRUCTURE OF A 2/1 APPROXIMANT IN THE Al-Pd-Mn-Si SYSTEM

Institute for Materials Research,
Tohoku University
K. Sugiyama, N. Kaji and K. Hiraga

The structure of icosahedral phases has been discussed on the basis of icosahedral atom clusters found in the crystal structures of $Al_{12}Mn$ (a = 0.8 nm) and α-AlMnSi (a = 1.2 nm). Recently, a cubic approximant (a = 2.0 nm) has been found in the Al-Pd-Mn-Si system, and larger icosahedral clusters are expected to be found in its structure. The purpose of this study is to analyze the structures of the cubic AlPdMnSi phase by means of single crystal X-ray diffraction and to discuss atomic arrangement. The structure of cubic $Al_{69.5}Pd_{23.0}Mn_{6.2}Si_{1.3}$ was determined by means of single crystal X-ray structural analysis: space group *Pm*3, a = 20.211(2)Å, Mo $K\alpha$; refined as $Al_{69.6}Pd_{24.4}Mn_{6.0}$, $R(wR2)$ = 0.0662(0.1744) for 2275 reflections with $I > 1.5s(I)$. The icosahedral cluster with about 20Å in diameter is found to locate at the origin of a unit cell. The atomic arrangement of the cluster can be described as nine atomic shells with icosahedral symmetry and some atomic shells are similar to those of Bergman and Mackay icosahedral clusters. The present cluster is suggested to be one of the basic structural units for the icosahedral quasicrystals in the Al-Pd-Mn-Si system.

(4) MATERIALS CHARACTERZATION BY TEM AT IAMP

Institute for Advanced Materials Processing,
Tohoku University
D. Shindo

In this talk, I would like to outline the research of atomic scale morphology analysis lab. First I will talk about characterization of monodispersed particles by TEM. By using ultramicrotomy, we obtained thin sections of the particles. With these thin sections, we could clarify the internal structure of the particles on atomic scale with high-voltage TEM. Secondly I would like to talk about the development of quantitative high-resolution TEM with a new recording system, i.e., imaging plates. Characteristics of the imaging plates, such as DQE (detective quantum efficiency), signal to noise ratio (S/N) were evaluated. Taking account of these characteristics of the imaging plates, we could carry out the quantitative analysis. In the analysis, a residual index between the observed and calculated images were evaluated. The smallest residual index 0.0304 was obtained for high-resolution TEM images of WO_3 block structure. I will also talk about the construction of the database of TEM images, i.e., "EMILIA : Electron Microscope Image Library and Archive". It will be pointed out that digital data of TEM images will be exchanged and shared through the internet.