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UNUSUAL GLASS FORMATION IN THE Al-Nd-O SYSTEM

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A new oxide glass in the Al-Nd-O system was made through fusing by arc plasma torch and rapid quenching by a particular device although, in this system, so far it was very difficult to realize the glassy state. Quenched material of about 5mm in diameter and about 1μ in thickness was examined by polarizing microscope and by X-ray diffraction technique. The results clearly showed the existence of the glassy state.

Quenching techniques to obtain the amorphous state in metals and ceramics have been studied for a long time. Sarjeant and Roy[1] have recently developed a rapid quenching technique, splat-quench, for oxide systems and obtained four new oxide glasses, V_2O_5, TeO_2, MoO_3 and WO_3. It is well known that the glassy state is obtained from oxide compounds or mixtures, containing B, Si, Ge, P and/or As etc, as network formers. However, it is very difficult to realize the glassy state in Al-Nd-O system. Then so far the glass formation in this system has not been reported.

The present authors tried to obtain the glassy state in the above mentioned Al-Nd-O system, by applying an improved rapid quenching technique giving higher quenching rate than that by Sarjeant and Roy. The apparatus used is shown schematically in Fig. 1. It consists essentially of two parts; one is an arc plasma torch and the other is composed of a piston and an anvil cooled by water. The equipment to fire an arc plasma flame is made by Linde (type-LPS 15/50H). The piston is worked by a spring which is released by an electromagnet.

The purity of aluminium oxide (α-Al_2O_3) and neodymium sesquioxide used in this experiment is higher than 99.9%. Ten different compositions were prepared from the powders of α-Al_2O_3 and Nd_2O_3. The batch ingredients were weighed on molar basis, Al_2O_3 : Nd_2O_3 = x : 1, where x is a whole number in the range of 1 to 10 and they were well mixed by mortar grinding. The batches were formed into pellets, 5mm in diameter and 1mm in thickness, by pressing at 4 ton/cm^2. The pellets were sintered at 1000°C for 5 hr, in air. The sintered pellet was put in the position as shown in Fig. 1, and then it was melted by the plasma flame till it

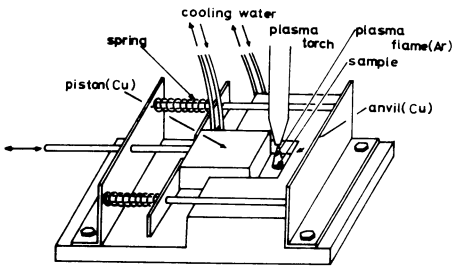

Fig. 1. Schematic diagram of the quenching apparatus, showing the arc plasma torch and the piston and anvil arrangement.

became almost spherical in shape. The melt was rapidly quenched by bringing the piston and anvil to work during firing by the plasma flame.

Thus a glassy material composed of Al_2O_3 and Nd_2O_3, of which molar ratio is x:1 (x=1-10), was obtained by the above method. The mean size of the quenched material is about 5mm in diameter and about 1μ in thickness and the samples are transparent for visible light. The specimens were examined by polarizing transmission-microscope, and it could be recognized that the material was to be a real glass, because all of the specimens had no birefringence under crossed Nicols as shown in Fig. 2.

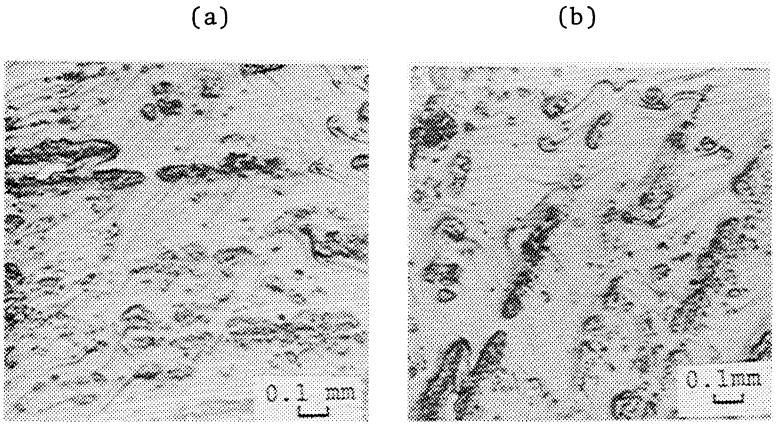

Fig. 2. Polarizing microscopic observation of quenched material Al_2O_3:Nd_2O_3=6:1. Specimen shown in (b) is rotated 60° with respect to (a).

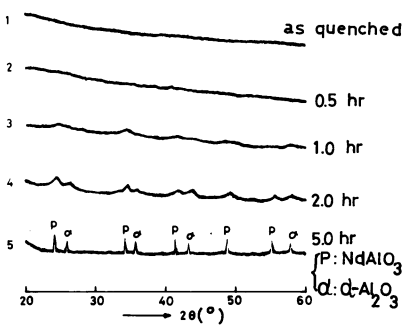

Fig. 3. X-ray diffraction patterns of $6Al_2O_3 \cdot Nd_2O_3$ quenched and subsequently annealed for different times at 1000°C.

Such a glassy state in the Al-Nd-O system was obtained in the whole range of x. As shown in Fig. 2, the composition, $6Al_2O_3 \cdot Nd_2O_3$, serves as a typical example. Furthermore, the isotropic materials were identified as glass by X-ray diffractometer technique using CuKα radiation (Ni filtered) with a pulse height analyzer. No diffraction peak was obtained through the whole range of 2θ-value measured as shown in Fig. 3-1.

Samples of $6Al_2O_3 \cdot Nd_2O_3$ were annealed in a platinum boat in an electric furnace at 1000°C for 0.5 to 10 hours in air. The annealed samples were analyzed by X-ray diffraction and the diffraction patterns for the various annealing times are shown in Figs. 3-2, 3-3, 3-4 and 3-5. With being prolonged time of annealing, the broad diffraction pattern of the original sample gradually changed its feature into that with a number of peaks. The pattern of the sample annealed for 5 hours developed many distinct peaks from which it could be identified as a mixture of $NdAlO_3$ and α-Al_2O_3.

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Reference

1) P. T. Sarjeant and R. Roy, J. Amer. Ceram. Soc., 50, 500 (1967).

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