CHEMISTRY LETTERS, pp. 449 - 450, 1984.

PREPARATION OF AMORPHOUS NICKEL FILM CATALYSTS BY GLOW DISCHARGE

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The thin film of nickel alloys was prepared using a RF glow discharge sputtering system that was discharged between the inside and the outside electrodes of a reaction cell. It was determined by X-ray diffraction pattern that the nickel films prepared by the discharge under B_2H_6 atmosphere became an amorphous state.

Amorphous alloys are new substances with potential properties which are of interest for basic solid-state physics, metallurgy, surface chemistry, and technology. It is well known that the amorphous alloys have many potentially useful properties including good corrossion resistance, high mechanical ductility, high magnetic permeability, and temperature-independent electrical conductivity which are quite unexpected for solid metals. These alloys are supposed to have dangling bonds based on the amorphous structure and therefore are expected to act as useful catalysts for several reactions. When these amorphous alloys were prepared as a thin film, a small amount of the amorphous alloys would be able to have a large surface area. This is the most effective way to use as a catalyst and a sensor.

These amorphous alloys are usually obtained by very rapid quenching (10^6 K s^{-1}) to produce thin splats or ribbons. The obtained splat is between 15 - 30 mm in diameter and 20 - 80 μm thickness [1,2] and the ribbons have typical dimention of 1 - 3 mm width and 20 - 60 um thickness.[3] These alloys therefore are not very thin film.

In the present report, the thin films of amorphous nickel alloys were prepared by sputtering, using a glow discharge. Accordingly, the film obtained will become very thin and its thickness will be able to be controlled under different conditions of the glow discharge.

The thin films of amorphous nickel employed here were prepared using a RF glow discharge sputtering system. The schematic drawing of the glow discharge reactor was shown in Fig. 1. The reactor was made of pyrex glass with a 40 mm

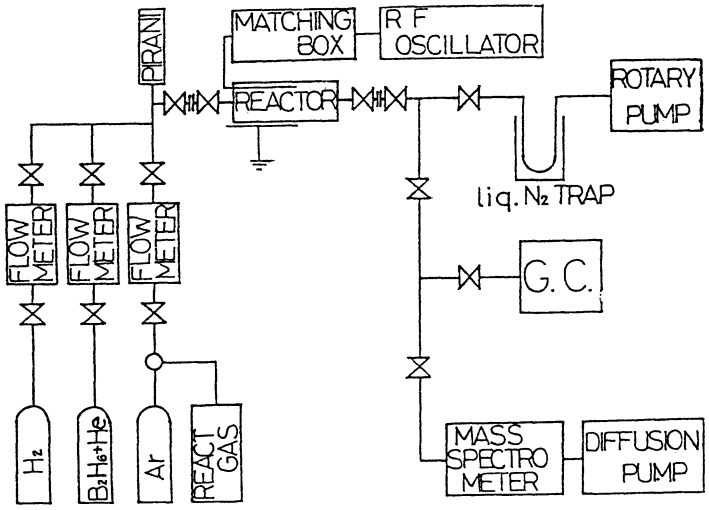

Fig. 1. Schematic drawing of glow discharge system.

in inside diameter and a 200 mm in length. The frequency of the RF oscillator (KOKUSAI DENKI, MV-050) was 13.56 MHz and its maximum electric power was 500 watt. The matching box was used in order to stabilize the glow discharge. The poisoneous B_2H_6 gas was trapped with liquid nitrogen trap. The sputtering atmosphere was a high purity of Ar (99.9995 %) at a pressure of 1 - 5 x 10^{-2} Torr and B_2H_6, 5.0 vol% diluted with He, 4 - 20 x 10^{-2} Torr. The gases were ionized by the glow discharge on an input power of 20 to 100 watt between two electrodes: one, a target of nickel plate (99.999 %) inside of a reactor, the other, a copper plate, the outside of the reactor. The analysis of gases was carried out using a quadrupole mass spectrometer (MSQ - 150A).

The X-ray diffraction patterns of the nickel plate used as the target and the nickel films prepared by the glow discharge under the conditions with or without B_2H_6 are shown in Fig. 2. The three peaks due to Miller index, (111), (200), and (220) appeared at 44.5°, 51.8°, and 76.5°, in the nickel plate and the nickel film sputtered in Ar stream without B_2H_6, but there was no peak in the film prepared by glow discharge under B_2H_6 atmosphere though these three peaks were also observed in the presence of a trace amount of oxigen under the similar conditions with B_2H_6 atmosphere (c). It is evident that the nickel film prepared by glow discharge under B_2H_6 atmosphere is a thin film with amorphous structures.

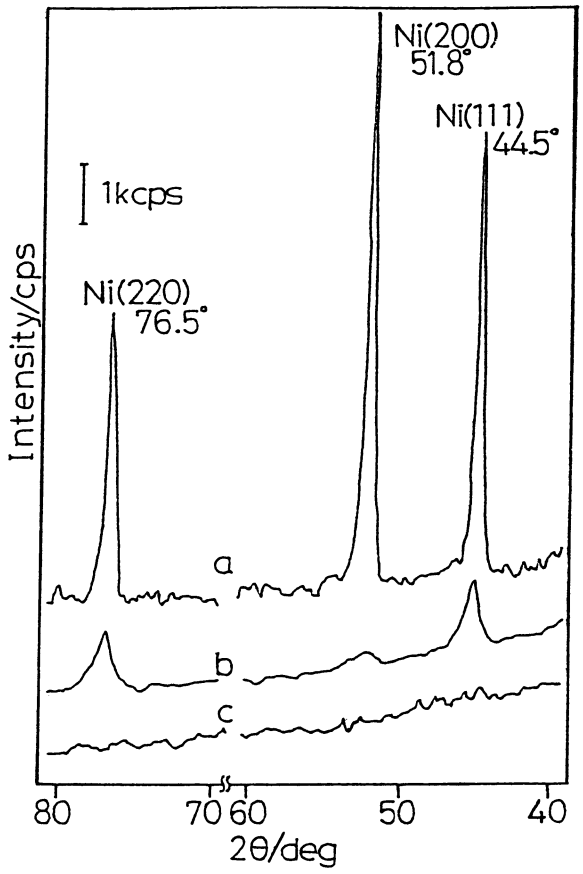

Fig. 2. X-Ray diffraction patterns of nickel metal and its amorphous film.
a) Nickel metal plate,
b) Nickel metal sputtered by Ar without B_2H_6 for 2h , Ar: 5.0 x 10^{-2} Torr,
c) Amorphous nickel film sputtered by Ar with B_2H_6 for 2h , B_2H_6 + He: 2.0 x 10^{-2} Torr, Ar: 5.0 x 10^{-2} Torr.

The preparation of amorphous alloy by the glow discharge will be able to apply all sorts of metal alloys. This promising field of research has just begun. Further studies are now in progress.

References

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(Received December 23, 1983)