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Technical Note

Effect of Chromium Addition on Corrosion Resistance of Amorphous Co-Zr Alloys†

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KEY WORDS; (Corrosion), (Amorphous Alloy), (Chromium), (Cobalt), (Passivity)

In the past few years the field of liquid quenching has been seen hundreds of publications on techniques of quenching, property measurements, and industrial applications. A number of metal alloy sytems have been formed in amorphous condition through rapid solidification. The amorphous alloys are also applicable to brazing filler metals[1]. One of the outstanding characteristics in the field is the high corrosion resistance of some amorphous alloys. Naka et al. [2], in reporting the first observation of corrosion behavior of amorphous alloys, have stated that amorphous $FeCrP_{13}C_7$ and $FeCrNiP_{13}C_7$ alloys containing 8 at. % or more chromium show an extremely high corrosion resistance in various enviroments, especially to pitting in acid and neutral solutions containing chloride. The studies of corrosion behavior of amorphous alloys have so far been focused on the metal-metalloids systems. On the other hand, Nose and Masumoto[3] have recently to prepare amorphous Co-rich Zr alloys without metalloids. These alloys possess excellent magnetic properties. Therefore, the corrosion properties of these alloys are worth examining. The present paper aims to clarify corrosion behavior of amorphous Co-Zr alloys.

Amorphous $Co_{90-X}Cr_XZr_{10}$ ($X = 0 \sim 30$) alloys of 1mm in width and 25 μm in thickness were prepared by a melt-spinning method. This technique consists of impinging a jet of molten alloy on the outer surface of a rapidly rotating cylinder. The formation of amorphous structure was confirmed by X-ray diffraction. The number attached to respective element denotes the nominal content in atomic percent.

Corrosion tests and electrochemical measurements were carried out in IN HCl, 3%NaCl, 1N H_2SO_4, 1N HNO_3 solutions, which were open to air. The solutions were prepared by using reagent grade chemicals and deionized water. A corrosion rate was estimated from measurements of the weight loss after immersion in the solutions at 303 K. Polarization curves were estimated by potentiodynamic method with a potential sweep rate of 2.5×10^{-3} Vs^{-1}, starting from the corrosin potential at room temperature.

Figure 1 shows the change in corrosion rate of amorphous $Co_{90-X}Cr_XZr_{10}$ alloys in IN HCl as a function of chormium content.
Included for comparison in the figure are corrosion rates of amorphous $Co_{80-X}Cr_XB_{20}$ and $Co_{80-X}Cr_XP_{13}C_7$ alloys. The corrosion rates of amorphous alloys containing phosphorus as a major metalloid element decrease effectively with an increase in chromium content. Immunity to corrosion in IN HCI is attained at 10 at . % chromium for $Co_{80-X}Cr_XP_{13}C_7$ alloys. When boron is added as a metalloid, alloying with chromium up to about 20 at.% is ineffective in increasing the corrosion resistance. With further increase in chromium content the corrosion rate of $Co_{80-X}Cr_XB_{20}$ alloys decreases and becomes undetectabe at 50 at.% chromium.

With an increase in chromium content the corrosion rates of amorphous $Co_{90-X}Cr_XZr_{10}$ alloys which compose of only metallic elements decrease gradually. In contrast to amorphous alloys containing phosphorus as major metalloid, addition of chromium is not effective in increasing the corrosin resistance.

Further examination of corrosion behavior was performed by potentiodynamic polarization measurements. **Figs. 2 and 3** show andic polarization curves of $Co_{90-X}Cr_XZr_{10}$ alloys in IN HCl and 3% NaCl,

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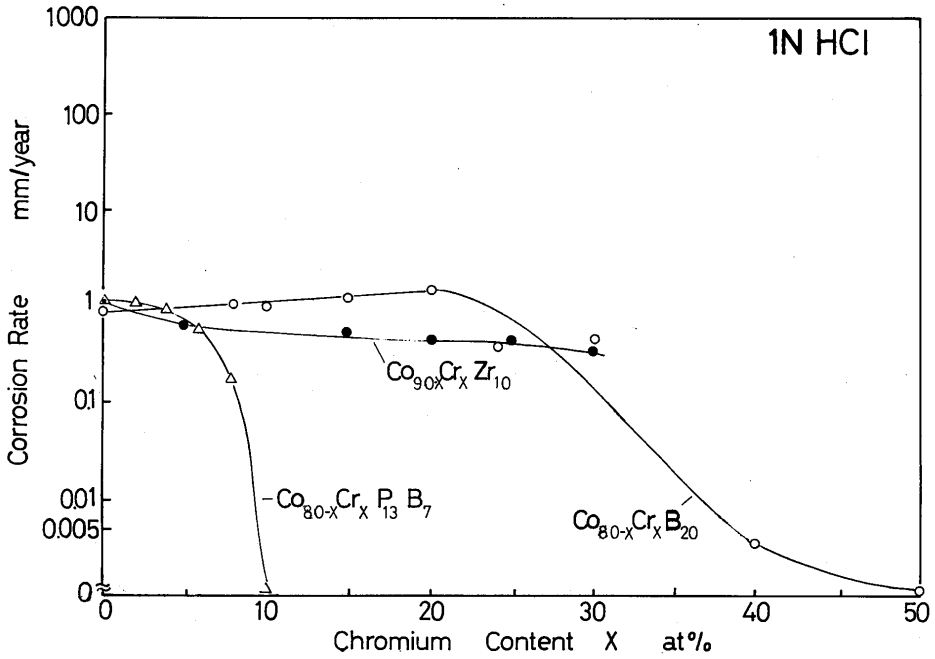

Fig. 1 Corrosion rates of amorphous $Co_{90-X}Cr_X Zr_{10}$, $Co_{80-X}Cr_X P_{13}C_7$ and $Co_{80-X}Cr_X B_{20}$ alloys in 1N HCl at 303 K.

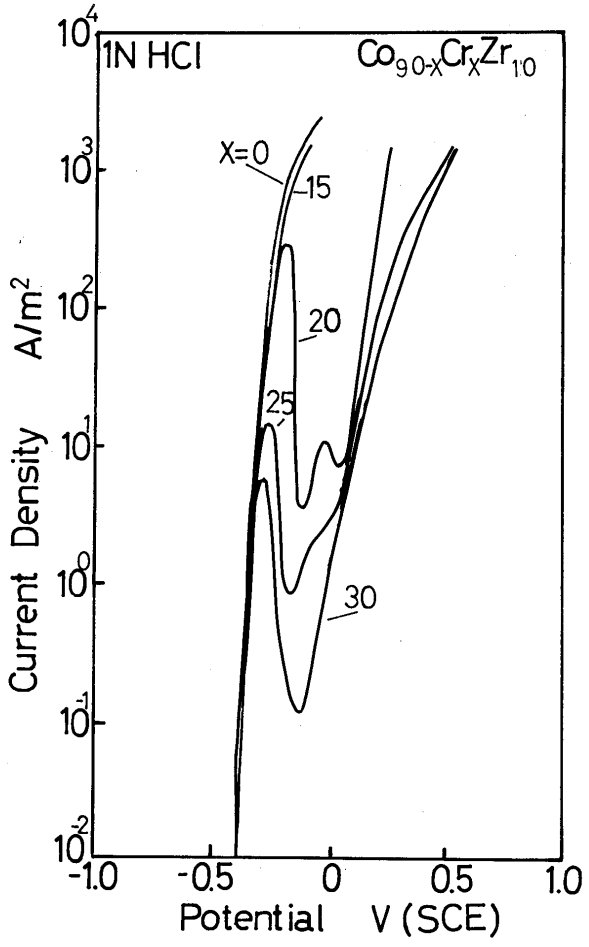

Fig. 2 Anodic polarization curves of amorphous $Co_{90-X}Cr_X Zr_{10}$ in 1N HCl.

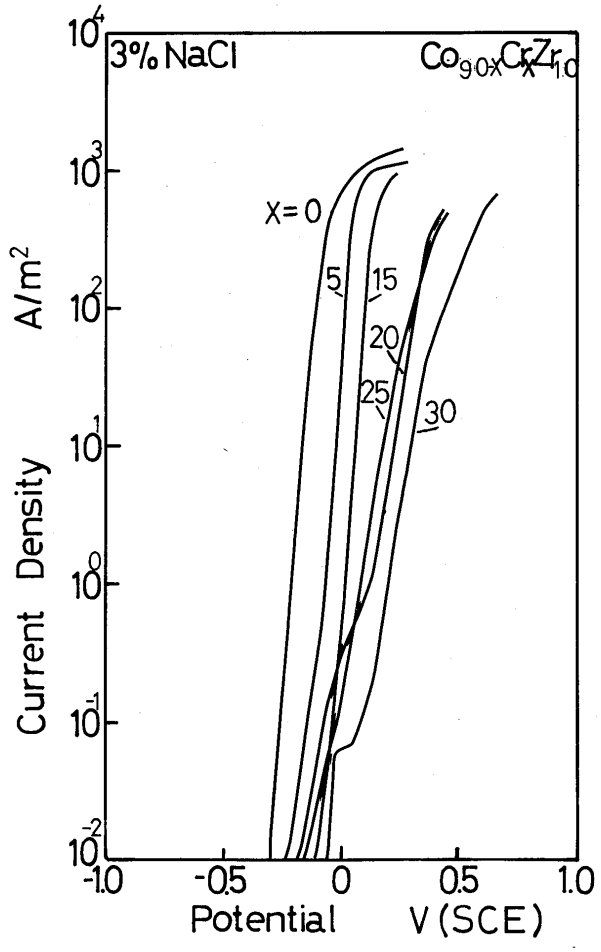

Fig. 3 Anodic polarization curves of amorphous $Co_{90-X}Cr_X Zr_{10}$ in 3% NaCl.

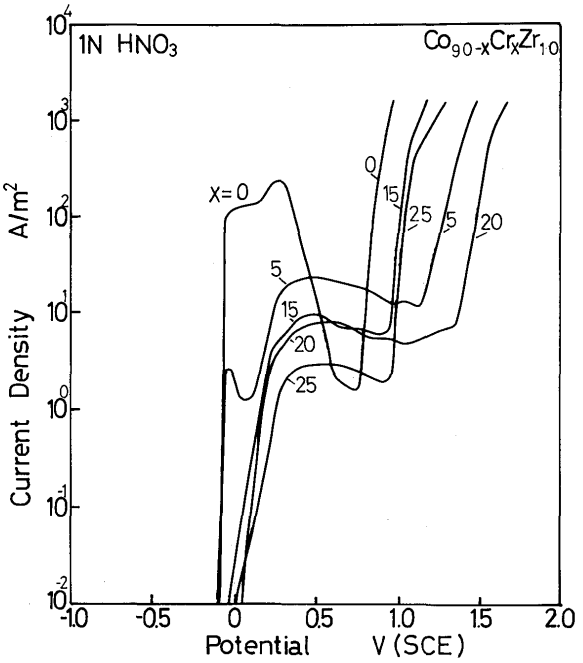

Fig. 4 Anodic polarization of amorphous $Co_{90-X}Cr_XZr_{10}$ in 1N HNO_3.

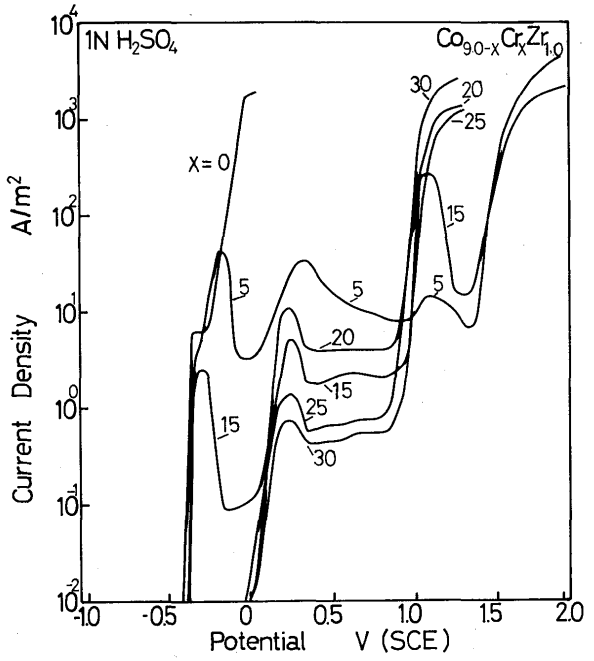

Fig. 5 Anodic polarization curves of amorphous Co_{90-X} Cr_X Zr_{10} in 1N H_2SO_4.

respectively. Though the passivation of amorphous Co-Zr alloys containing 20 at.% chromium in IN HCl takes place and the anodic current densities decrease with an increase in chromium content, an abrupt increase in anodic current density due to pitting corrosion occurs as shown in **Fig. 2.** The corrosion potentials and anodic current densities without the passivation decrease gradually with an increase in chromium content in 3% NaCl as shown in **Fig. 3.** In acids such as 1N HNO_3 and 1N H_2SO_4 without chloride the passivation takes place and the anodic current densities decrease with an increase in chromium content as show in **Figs. 4 and 5.**

The amorphous structure and the presence of zirconium is attributable to the improvement of amorphous $Co_{90-X}Cr_XZr_{10}$ alloys. However, the corrosion rate of amorphous Co-Cr-Zr alloys is higher than that of amorphous Co-Cr alloys containing phosphorus. This arises from that the active dissolution to passivation of amorphous Co-Cr-Zr alloys is not enough to enrich the chromium in the suface of the alloys during immersion.

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