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PRESSURE EFFECT ON CURIE TEMPERATURE FOR $\text{Co}_{1-x}\text{B}_x$ AMORPHOUS ALLOYS

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Abstract. – Pressure effect on Curie temperature, $dT_c/dp$, for amorphous $\text{Co}_{1-x}\text{B}_x$ alloys is estimated indirectly from forced volume magnetostriction even in $T_c > T_{\text{cry}}$. Results estimated indirectly show smaller values compared with those measured directly, and are consistent with thermal expansion. The value of $dT_c/dp$ extrapolated to Co agrees with that for crystalline Co.

1. Introduction

Pressure effect on Curie temperature $T_c$, $dT_c/dp$, for Co base amorphous (CoTm)$_{90}$Zr$_{10}$ (Tm = Cr, Mo) alloys has been investigated directly [1] and indirectly from forced volume magnetostriction $d\omega/dH$ [2]. However, the results show the large difference between direct and indirect measurements in Co-rich region. Invar character will be expected from the larger $dT_c/dp$ measured directly, but there is no indication that Invar character appears from the smaller $dT_c/dp$ estimated indirectly and the results of thermal expansion [1]. In this paper, therefore, $dT_c/dp$ for more simple $\text{Co}_{1-x}\text{B}_x$ amorphous alloys is estimated indirectly from $d\omega/dH$ using the Kornetzki-Kouvel’s relation [3] even in $T_c > T_{\text{cry}}$, crystallization temperature, and is compared with that measured directly [1] to clarify the behavior of $dT_c/dp$ for Co base amorphous alloys. In fact, amorphous $\text{Co}_{1-x}\text{B}_x$ alloys have higher $T_c$ than $T_{\text{cry}}$ in the composition region of $x < 0.28$ of B [4, 5] where $dT_c/dp$ cannot be measured directly.

2. Experiments

Specimens prepared by the single-roller quenching technique were amorphous $\text{Co}_{1-x}\text{B}_x$ ($0.16 \leq x \leq 0.34$) and in the form of ribbons 1-2 mm wide. Ribbons 22 mm long were used as samples. Measurements of $d\omega/dH$ were done by the three-terminal capacitance method [6] in fields up to 18 kOe and at temperatures from 4.2 K to $T_c$ or $T_{\text{cry}}$.

3. Results and discussion

In figure 1, magnetic moment per Co atom $n$, $T_c$ and $T_{\text{cry}}$ for amorphous $\text{Co}_{1-x}\text{B}_x$ alloys are shown as a function of B content $x$, together with the results published [4, 5]. It must be noticed that $T_c$ is higher than $T_{\text{cry}}$ up to B content $x = 0.28$ where $dT_c/dp$ cannot be measured directly. Curie temperature $T_c$ in $T_c > T_{\text{cry}}$ was estimated from the temperature dependence of magnetization up to $T_{\text{cry}}$ using Brillouin function. The results of $n$, $T_c$ and $T_{\text{cry}}$ agree well with references [4, 5]. The values of $n$ and $T_c$ extrapolated to Co seem to agree with those for crystalline Co.

In figure 2, temperature dependences of $d\omega/dH$ for amorphous $\text{Co}_{1-x}\text{B}_x$ alloys are shown. Values of $d\omega/dH$ decrease with increasing $T/T_c$ and seem to take the minimum at $T_c$ for specimens in $T_c > T_{\text{cry}}$ ($x < 0.28$), but they increase with increasing $T/T_c$ and take the sharp peak at $T_c$ for specimens in $T_c < T_{\text{cry}}$ ($x \geq 0.28$). From these results, pressure effects on magnetic moment per gram $\sigma_0$ at 0 K, $d \ln \sigma_0/dp$, and on $T_c$, $dT_c/dp$, can be estimated indirectly using the Kornetzki-Kouvel’s relation [3] even in $T_c > T_{\text{cry}}$.
and
\[ \frac{d\omega}{dH} = \rho \sigma_s [T (d \ln \sigma_0 / dT) 
\times (d \ln T_c / dp) - d \ln \sigma_0 / dp] \]

In this paper, only \( dT_c / dp \) is described and \( d \ln \sigma_0 / dp \) will be done elsewhere.

In figure 3, values of \( dT_c / dp \) estimated indirectly for amorphous \( \text{Co}_{100-x}\text{B}_x \) alloys are shown as a function of Co content, together with those measured directly for amorphous \( \text{Co}_{68}\text{B}_{34} \) alloy [1] and crystalline Co [7]. And are also shown together with those obtained directly and indirectly for amorphous \( \text{(CoTm)}_{90}\text{Zr}_{10} \) \((\text{Tm} = \text{Cr}, \text{Mo})\) alloys [1, 2].

For amorphous \( \text{Co}_{100-x}\text{B}_x \) alloys, there is the large difference between the values of \( dT_c / dp \) obtained directly and indirectly. The smaller values of \( dT_c / dp \) estimated indirectly are consistent with the results of thermal expansion as described in reference [2].

For amorphous \( \text{Co}_{100-x}\text{B}_x \) alloys, there is also the difference between the values of \( dT_c / dp \) obtained directly and indirectly. That is, -0.8 and -0.1 K/kbar obtained directly and indirectly for amorphous \( \text{Co}_{68}\text{B}_{34} \) alloys, respectively. Due to the results of thermal expansion [1], there is no indication that the gap of thermal expansion coefficient at \( T_c \) appears in the Ehrenfest’s equation. Therefore, it cannot be expected almost for \( dT_c / dp \) to exist, and the smaller value of \( dT_c / dp \) estimated indirectly from \( d\omega / dH \) is thought to be reasonable one than the larger one measured directly.

Finally, in figure 3, when the values of \( dT_c / dp \) estimated indirectly for amorphous \( \text{Co}_{100-x}\text{B}_x \) and \( \text{(CoTm)}_{90}\text{Zr}_{10} \) \((\text{Tm} = \text{Cr}, \text{Mo})\) alloys are extrapolated to Co, it is very interesting that the converged value of \( dT_c / dp \) agrees with that for crystalline Co [7]. This means that magnetic properties of amorphous Co are equal to those of crystalline Co.