Neutron Diffraction with the Metallic Glass $Ni_{81}B_{19}$ Using Isotopic Substitution

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In the field of structural research of metallic $T_{80}M_{20}$-glasses (T = Fe, Co, Ni; M = B, P) at the moment large interest exists in the determination of the so called partial structure factors S_{mn}, especially of the structure factor S_{MM} which is determined by the arrangement of the metalloid atoms. Since the mathematical evaluation of S_{MM} from three measured total structur factors is rather uncertain, in [1] a method was proposed for the direct measuring of S_{BB} in $Ni_{81}B_{19}$, the experimental realization of which will be reported in the present paper.

Specimen Preparation

Using the boron isotope ^{11}B (scattering length $b_{^{11}B} = +0.6 \cdot 10^{-12}$ cm) and nickel with different isotopic composition, the three following alloys were prepared.

i) $^{nat}Ni_{81}{}^{11}B_{19}$ ($b_{^{nat}Ni} = +1.03 \cdot 10^{-12}$ cm).

ii) By alloying of the nickel isotopes ^{62}Ni and ^{60}Ni a "zero nickel" ØNi was produced which shows the coherent scattering length $b_{ØNi} = 0$. This zero nickel was used to produce $ØNi_{81}{}^{11}B_{19}$.

iii) $^{62}Ni_{81}{}^{11}B_{19}$. The isotopic abundance of the mixture designed with ^{62}Ni amounted to 99.0% and the scattering length was $b_{^{62}Ni} = -0.85 \cdot 10^{-12}$ cm.

In a melt spin apparatus from these alloys under He-atmosphere metallic glasses were produced using identical experimental conditions. The masses were 9.5 (i), 9.2 (ii) and 4 g (iii), respectively, the breadth of the ribbons was 1.5 mm, and their thickness 12 up to 14 µm. The ribbons were cut into pieces with 5 mm length, and then these pieces were pressed into hollow cylinders (outer diameter 11.5 mm, wall thickness 0.1 mm, length 42 mm) made from vanadium foil.

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Performance of the Experiments and Measured Intensities

The specimens were investigated at roomtemperature by means of neutron diffraction using the D2-instrument (see [2]) which is installed at the high flux reactor of the ILL, Grenoble. The wavelengths were $\lambda_1 = 1.22$ Å and $\lambda_2 = 0.824$ Å. The Q-regions

were $0.3\,\text{Å}^{-1} \leqq Q \leqq 8.9\,\text{Å}^{-1}$ for λ_1
and $5.02\,\text{Å} \leqq Q \leqq 13.21\,\text{Å}^{-1}$ for λ_2,

with $Q = 4\pi(\sin\theta)/\lambda$, 2θ being the scattering angle. In Figs. 1 and 2 the measured intensity curves obtained with the three specimens and the two wavelengths are plotted using arbitrary units.

Discussion of the Intensity Curves

In (1) to (3) for each of the three specimens the calculation of the Faber Ziman total structure factors S_{i}^{FZ}, S_{ii}^{FZ}, and S_{iii}^{FZ} from the three partial structure factors S_{mn} is shown:

$$S_{i}^{FZ} = 0.77\,S_{NiNi} + 0.013\,S_{BB} + 0.21\,S_{BNi}, \quad (1)$$

$$S_{ii}^{FZ} = S_{BB}, \quad (2)$$

$$S_{iii}^{FZ} = 1.45\,S_{NiNi} + 0.042\,S_{BB} - 0.49\,S_{BNi}. \quad (3)$$

It can be clearly seen that in (1) and (3) (curves a and c in Figs. 1 and 2) the contribution of the boron-boron correlation is negligible. From (2) however, it follows that the curve b corresponds directly to the partial function S_{BB}. Curve b shows a broad maximum at the low Q-value of about 2.15 Å^{-1} which corresponds to a rather large boron-boron distance of about 3.6 Å. Furthermore curve b shows a significant minimum, which nearly coincides with the first maxima in the curves a and c.

The comparison of curve a and c shows that the curve c, in which according to (3) the contribution of the partial structure factor S_{BNi} is negative, the first maximum is very unsymmetrical. Furthermore the oscillations in curve c are much more pronounced.

The Eqs. (1) to (3) represent a good starting point for the evaluation of the three partial structure factors which is done at present.

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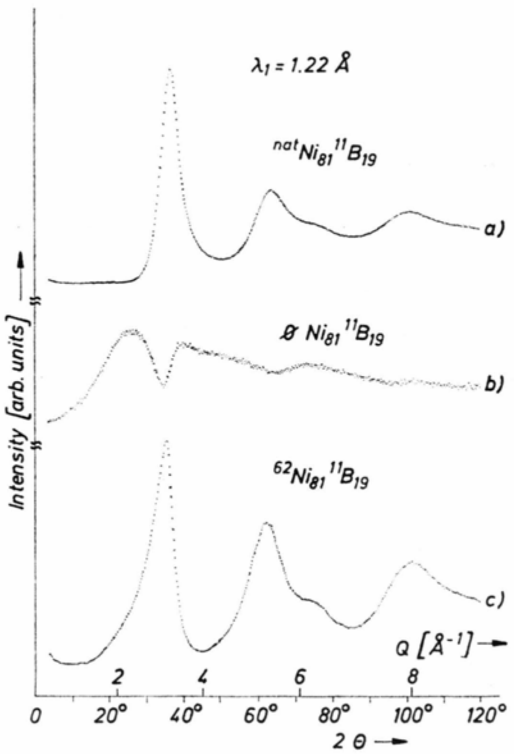

Fig. 1. $^{nat}Ni_{81}{}^{11}B_{19}$, $ØNi_{81}{}^{11}B_{19}$, $^{62}Ni_{81}{}^{11}B_{19}$: Intensity vs. 2θ using $\lambda_1 = 1.22$ Å.

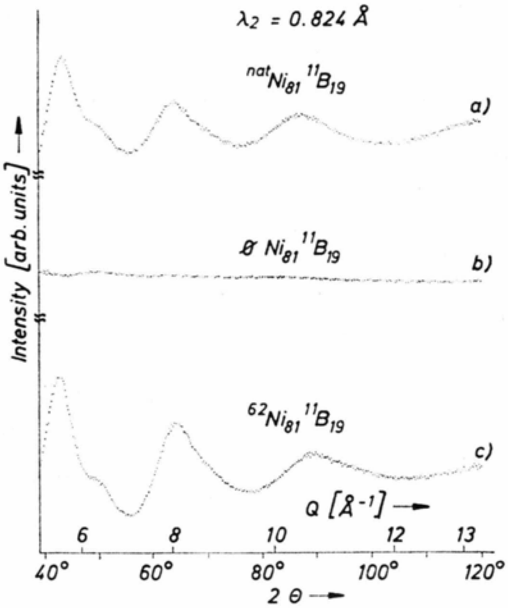

Fig. 2. $^{nat}Ni_{81}{}^{11}B_{19}$, $ØNi_{81}{}^{11}B_{19}$, $^{62}Ni_{81}{}^{11}B_{19}$: Intensity vs. 2θ using $\lambda_2 = 0.824$ Å.

Acknowledgements

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[1] P. Lamparter, W. Sperl, G. Rainer-Harbach, and S. Steeb, ILL Research proposal 6-08-54 from 13. 05. 1980.

[2] ILL-Neutron Beam Facilities Available for Users; Edition January 1981, Grenoble.

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