ELECTRON MICROPROBE INVESTIGATIONS OF
INTERFACIAL REACTIONS IN SYSTEMS COMPOSED
OF A REFRACTORY COMPOUND AND A LIQUID METAL
2. EFFECTS OF OXIDE FILMS ON THE CHARACTER OF THE
INTERFACIAL REACTION IN THE SYSTEM CrB$_2$-Ni

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Chromium reacts with boron to form a number of boride phases [1], of which the most stable, from a
thermodynamic standpoint, is chromium diboride - a compound possessing high oxidation resistance and
good resistance to corrosion in aggressive environments [2, 3]. Heat resistant cermets based on chromium
borides with nickel, nickel-copper, and nickel-chromium binders have been developed [4, 5] and are being
used at high temperatures under conditions of frequent and sharp temperature changes [6, 7]. Chromium
borides also find their application as wear-resistant facing materials for steel components [8], whose wear
resistance is two to three times that of Stalinit.* In spite of the wide use of chromium borides in various
branches of industry and technology, no systematic data have as yet been published on the reactions of
chromium borides with liquid metals and alloys.

The system CrB$_2$-Ni has been studied by Post and coauthors [9] and by Kiessling [10], who note the
possibility of formation of the ternary borides Cr$_2$NiB$_4$ and Cr$_2$Ni$_{6/5}$B$_4$, which can be detected by x-ray dif-
fraction. A more detailed investigation of the system Cr-Ni-B was carried out by Chepiga and his collabor-
ators [11], who discovered, by x-ray structural analysis, two ternary borides - Cr$_2$NiB$_4$ and Cr$_2$Ni$_3$B$_6$.
The first of these compounds is considered by the authors to be close in composition to the boride Cr$_2$NiB$_4$.
Kiparisov and co-workers [12] give data concerning the reactions of chromium mono- and diborides with
liquid nickel, iron, and iron-nickel alloys and show that transition metals vigorously react with the borides.
Samsonov and coauthors [13] have demonstrated that transition metals readily wet CrB$_2$, forming angles of
contact much smaller than 90°, which is evidence for the existence of chemical reactions in these systems.
A microstructural analysis of the reaction zone revealed two phases - a nickel base phase with a micro-
hardness of ~1000 kg/mm$^2$ and a chromium diboride base phase, whose microhardness $H_B$ ~3300 kg/mm$^2$,
was twice that of the starting diboride. The reaction products were not subjected to phase analysis.

In the present work, an electron microprobe study was made, using a Geol JXA-5 analyzer, of the
contact reaction zone in the system CrB$_2$-Ni. The experimental procedure employed was similar to that
described in Part 1 [14]. The phase composition of the reaction products was determined by the Debye x-ray
diffraction technique.

It was established that boron dissolves in a drop of liquid nickel, with the formation of the boride Ni$_3$B.
At the same time, nickel boride was found to react with chromium. The solubility of chromium in the bor-
ide is ~ 2 wt.%, the microhardness of this phase being ~1200 kg/mm$^2$. The reaction zone has a two-phase
structure (Fig. 1) composed of a solid solution of chromium in nickel boride and an $x$-phase - a complex
boride Cr$_x$Ni$_y$B$_z$, whose microhardness, 3300-4000 kg/mm$^2$, is 2.5 times that of the starting chromium di-
boride. The ternary boride solidifies in the form of acicular crystals of variable nickel content from 7 to

* A hard-facing material containing 8-10% C, 13-17% Mn, 3% Si, 16-20% Cr, balance iron - Translator.

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The chromium content of the ternary boride varies accordingly from 78 to 60 wt. %, while the amount of boron lies in the range 17-19 wt. %. The ternary boride is represented by the formula Cr$_{2+x}$Ni$_y$B$_4$, where 0.8 $\leq x \leq$ 1 and 0.3 $\leq y < 1$, and is thus a variable-composition phase having a wide range of homogeneity.

It is interesting to note one characteristic feature of the distribution of the x phase in the reaction zone. Near the boundary with the drop, the amount of newly formed x phase is less and the crystals are coarser; on moving toward the chromium diboride, the amount of the new phase grows and the crystal size decreases. The variation of nickel concentration at the lower boundary of the reaction zone for the system CrB$_2$-Ni is illustrated in Fig. 2, from which it can be seen that the intensity of nickel emission in the x phase reaches a maximum and then sharply falls to the noise level on passing to the chromium diboride.