



Glass composition dependence of metal corrosion by molten glass

Renaud Podor, Nicolas David, Christophe Rapin, Patrice Berthod, Pierre Steinmetz

► To cite this version:

Renaud Podor, Nicolas David, Christophe Rapin, Patrice Berthod, Pierre Steinmetz. Glass composition dependence of metal corrosion by molten glass. 7th International Conference “Advances in Fusion and Processing of Glass, Jun 2003, Rochester, United States. hal-04033802

HAL Id: hal-04033802

<https://hal.science/hal-04033802>

Submitted on 17 Mar 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

R. PODOR, N. DAVID, C. RAPIN, P. BERTHOD and P. STEINMETZ
Boulevard des Aiguillettes - B.P. 239 - F-54506 VANDOEUVRE-LES-NANCY CEDEX (France)

➤ The knowledge of the corrosion behavior of metals in molten glass is an important challenge for the glass industry. If the corrosion reactions can be predicted from both immersed material and glass composition, this would be a great advance in this field. A series of four metals have been immersed in six different glasses. The results reported herein point out the effect of the addition of an oxidant to the glass and of the glass basicity upon metal corrosion.

EXPERIMENTAL PROCEDURE

➤ The metallic plates are directly immersed in molten glass in order to limit its oxidation before diving.
➤ After the immersion test, cross-sections are realized in order to determine :

➤ Substrate thickness from direct measurements (optical microscope, SEM)



➤ Corrosion layer morphologies (SEM)

➤ Determination of the corrosion layer and substrate compositions (EPMA)

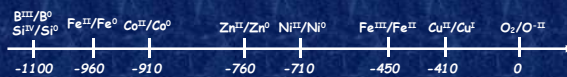
Glass compositions expressed in weight percent

	SiO ₂	B ₂ O ₃	Al ₂ O ₃	Li ₂ O	Na ₂ O	K ₂ O	CaO	ZnO	Fe ₂ O ₃	ZrO ₂
G-Zn	58.8	18.2	4.3	2.6	7.0	-	5.2	3.2	-	0.7
G-Fe	46.5	18.5	10.0	-	20.0	-	-	-	5.0	-
G-S	64.5	4.5	3.40	-	16.0	1.20	7.2	-	0.15	-
G-A	70.5	-	-	-	29.5	-	-	-	-	-
G-B	66	-	-	-	34	-	-	-	-	-
G-C	59.2	-	-	-	40.8	-	-	-	-	-

STUDY OF THE METAL/GLASS INTERFACES

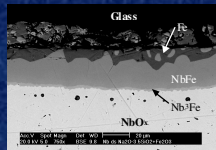
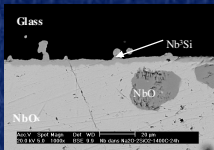
- Determination of the phases formed at the metal/glass interface during the immersion (T=1400°C)
- Interpretation of the morphologies referring to both redox couple scale and diffusion paths through the phase equilibria diagrams

Partial scale of redox couple potentials



Nb in G-A

➤ Si^{IV}/Si⁰

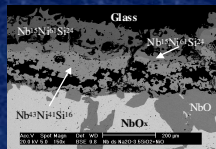


Nb in G-A + Fe₂O₃

➤ Fe^{II}/Fe⁰

Nb in G-A + CoO

➤ Co^{II}/Co⁰

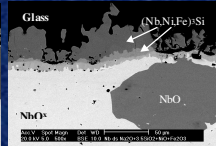
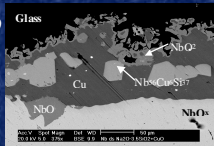


Nb in G-A + NiO

➤ Ni^{II}/Ni⁰

Nb in G-A + Cu₂O

➤ Cu^I/Cu⁰



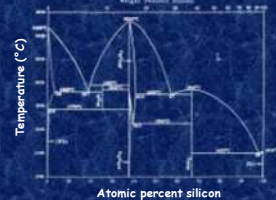
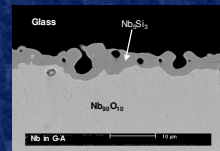
Nb in G-A + NiO + Fe₂O₃

➤ Ni^{II}/Ni⁰

➤ Fe^{II}/Fe⁰

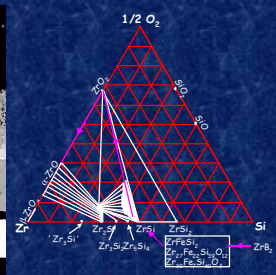
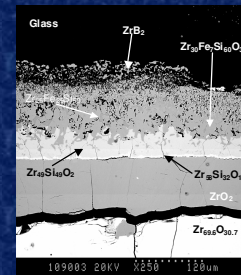
- Metals react with the redox couples present in the glass which potential is the higher in the scale
- Two elements can be deposited at the same time on the metal

Simple case : Niobium in G-A



- Metallic silicon reacts with Nb to form Nb₅Si₃
- Oxygen diffuses in Nb to form NbO_x

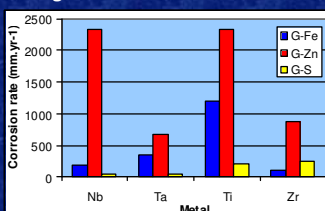
Complex case : Zirconium in G-Fe



- Fe, Si and B form during redox reactions
- Complex layers develop according to the Zr-Si-(Fe-B)-O phase diagram

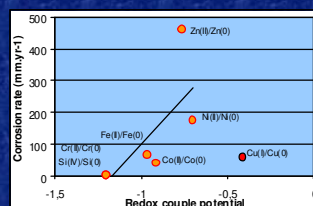
CORROSION KINETICS

➤ The corrosion rates are reckoned thanks to thickness measurements determined after two hours of metal/glass contact.



- Corrosion rates in G-Zn > G-Fe > G-S
- Corrosion rate depends on the considered metal/glass couple, that is to say, of the corrosion mechanism.

➤ Case of niobium immersion in Na₂O - 3.5SiO₂ (G-A) modified by metal oxide additions



- The corrosion rates are correlated with the redox potentials of the M^{II}/M⁰ couples. The higher the difference between the Nb^{II}/Nb⁰ potential and the M^{II}/M⁰ potential is, the higher the corrosion rate is.

CONCLUSIONS

- The morphology of the metal/glass interface depends on immersion duration, immersion temperature, the metal and the glass composition.
- The corrosion rates depend on the redox reactions involved in the metal corrosion by molten glass.
- The first results trying to correlate the corrosion rates and glass basicity are not self-consistent.
- The metal corrosion by molten glass can be used to deposit complex layers at the metal surface or to partially oxidize the metal.