Quality Evaluation of Self-Bonded SiC as Sidelining Materials in Aluminium Electrolysis Cells

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Abstract

Use of Si_3N_4-SiC is today the state of the art as sidelining materials in modern aluminium electrolysis cells. An alternative can be to use self-bonded SiC sidelining materials. A test program has been developed at SINTEF to test physical and chemical materials properties of ceramic materials. Open porosity, density, thermal expansion, thermal conductivity, oxidation resistance and chemical resistance have been measured for a self-bonded SiC material (Sicatec 95). In addition, mineral phase analysis has been performed using both XRD and LECO analysis (total O and total N) together with microstructure studies performed by SEM. In this article, the materials properties measured on self-bonded SiC will be compared to the ones of Silicon-nitride bonded SiC and industrial relevance will be discussed.

Keywords: Aluminum electrolysis cells, Sidelining materials, Self-bonded SiC

1. Introduction

With increased cell sizes and higher needs of increased productivity the performance of the cathode lining materials is more and more important and crucial for design of aluminium reduction cells. The sidelining materials today is mainly based on ceramic linings with Si_3N_4-SiC as state of the art. However, we have seen quality issues with these kind of materials due to variable microstructure and weak chemical resistance when no side ledge is present. Therefore, there is a need for an alternative material with better chemical resistance and higher thermal conductivity.

Self-bonded SiC may be an alternative material. This paper will present properties of such a material using different laboratory test methods.

2. Production of Self-Bonded SiC and Material Microstructure

Self-bonded SiC blocks are mainly produced by a mixture of SiC grains, powder (2.5–1.43 mm, 1.43–0.5 mm, 0.5–0 mm for grains, and less than 45 µm for the powder) and metal Si powder (less than 45 µm) and a binder. The binder (phenolic resin with residual carbon around 40 %) acts as a temporary bond of the green block and as the source of carbon for the formation of β-SiC. The green blocks are produced by pressing and vibrating, then dried and fired in inert (argon) atmosphere under several temperature stages up to 1400–1420 °C. N_2 gas is used for the cooling-down to protect the blocks from oxidation, and also consumes the potential residual Si to form Si_3N_4 or Si_2ON_2 (O is mainly from SiO_2 in the raw materials). The final block contains around 94–96 % of SiC and a small amount of Si_2ON_2. Fibrous β-SiC (together with Si_2ON_2) intervene and form a three-dimensional network wrapping up the SiC grains. The microstructure obtained by SEM is shown in Figure 1.

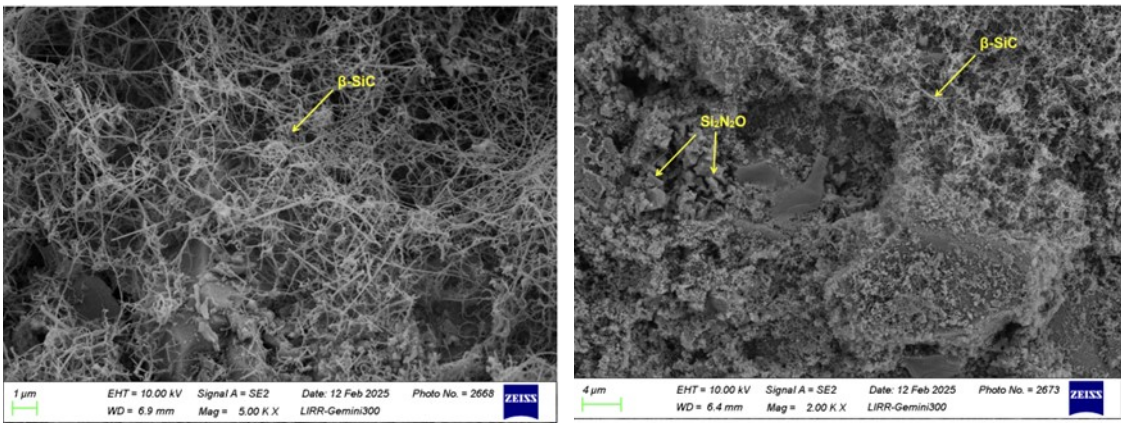

Figure 1. Microstructure of self-bonded SiC. SEM by LIRR.

XRD analysis performed by the Luoyang Institute of Refractories Research (LIRR) show contents of SiC and Si_2ON_2 as illustrated in Figure 2.

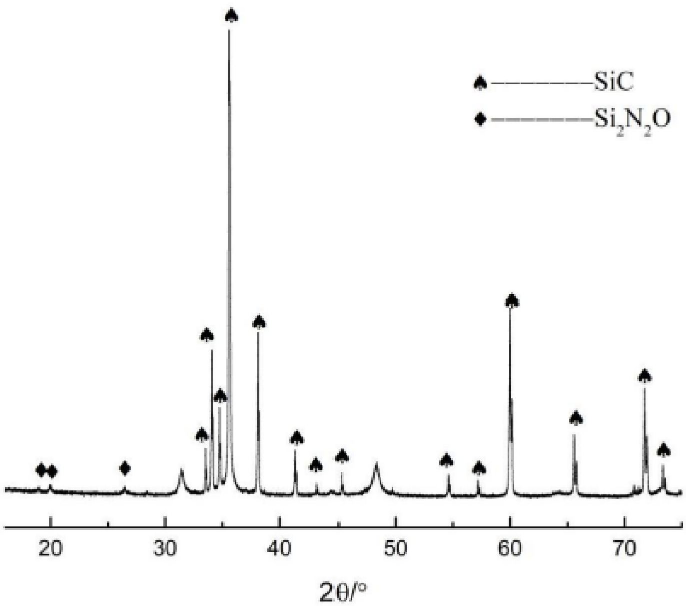

Figure 2. XRD-analysis performed by LIRR.

SINTEF performed XRD Rietveld and LECO analysis of 2 samples marked outer and inner (see Figure 3). The results are shown in Table 1.

Table 1. XRD and LECO analysis of 2 samples.

Sample	LECO (wt %)		XRD Rietveld (wt %)		
	O	N	SiC	Si_2ON_2	Si
Outer	1.52 ± 0.03	1.63 ± 0.06	93.7	6.2	0.1
Inner	1.36 ± 0.01	1.50 ± 0.03	92.6	7.3	0.1

The analysis confirmed content of mainly SiC, some Si_2ON_2 and small amount of Si.

6. References

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