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Protective coatings based on CrN for current collector materials of molten carbonate fuel cells

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INTRODUCTION

Bipolar plates and current collectors are critical metallic components for commercial MCFC stacks. In fact for commercial MCFC systems, up to 55 % of the material content could be the metallic hardware (for the complete system). The stability in a corrosive carbonate atmosphere at high temperature, good electrical conductivity and low contact resistance with the electrodes are desired characteristics of bipolar plates and current collectors. The bipolar plates are exposed to different atmospheres on the anodic side, cathodic side, and wet seal area of MCFC, and hence the ideal material for bipolar plate current collectors should have acceptable corrosion resistance for all of these atmospheres. Stainless steels like 310 S (24–26 wt. % Cr) and 304 L (16–18 wt. % Cr) have emerged as materials of choice for MCFC hardware. However, the hot corrosion in the presence of the carbonate melt is a critical issue with these materials for long-term operation (Fig.1).

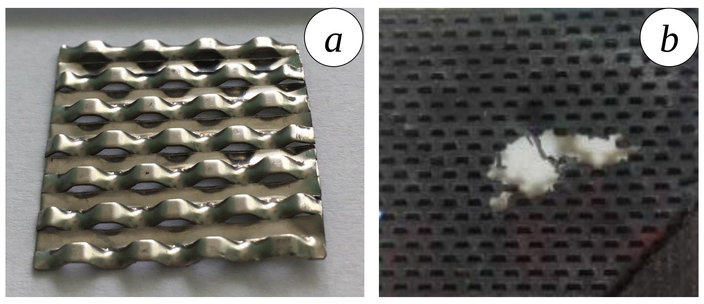


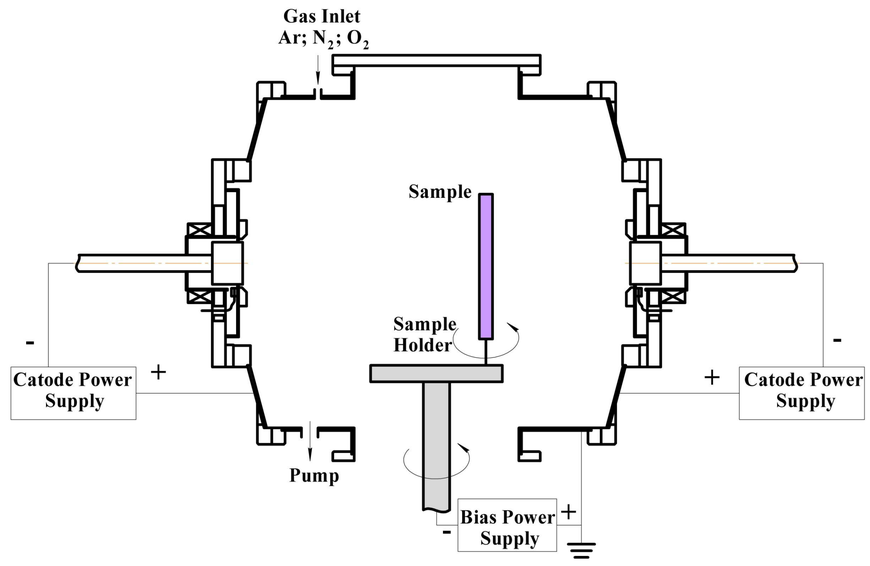
Fig.1 Current collector in the initial state (*a*) and after long-term operation (*b*).

One of the methods of protecting and improving the corrosion properties of steel is the application of coatings based on nitrides. The corrosion resistance of Cr-N coatings is better than that of stainless steel and other nitride coatings in the high temperature pressurized water and the oxidation rate in air at 600/800°C is low.

EXPERIMENTAL DETAILS

One of the most commonly deposition technique used is cathodic arc evaporation due to excellent characteristics of the coatings. The coatings are characterized by high hardness, good adhesion to the substrate, high density, homogeneity.

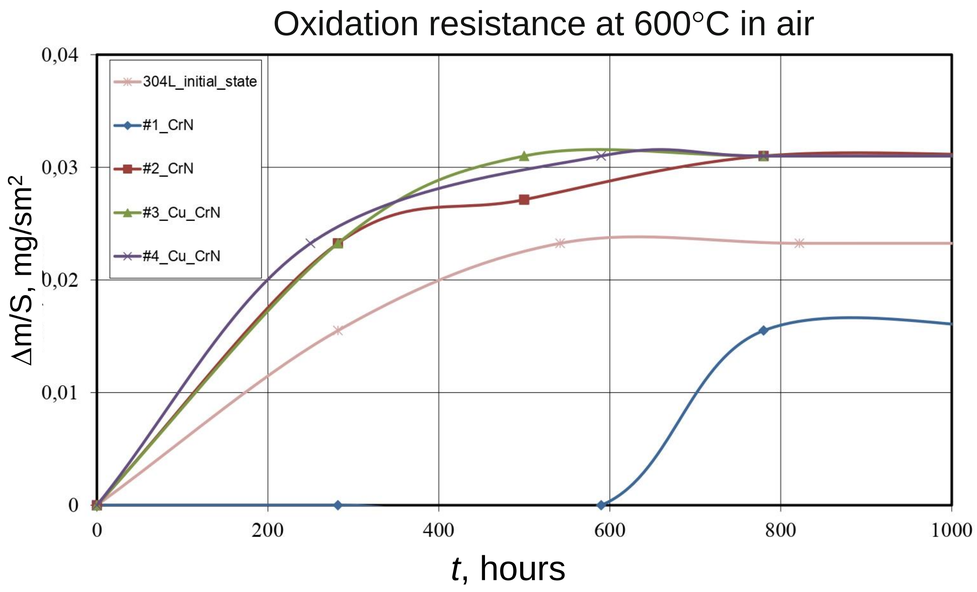
- Cathodic arc evaporation – Bulat 3,
- Substrate – stainless steel 304L,
- Substrate heating - up to 300 ˚C.

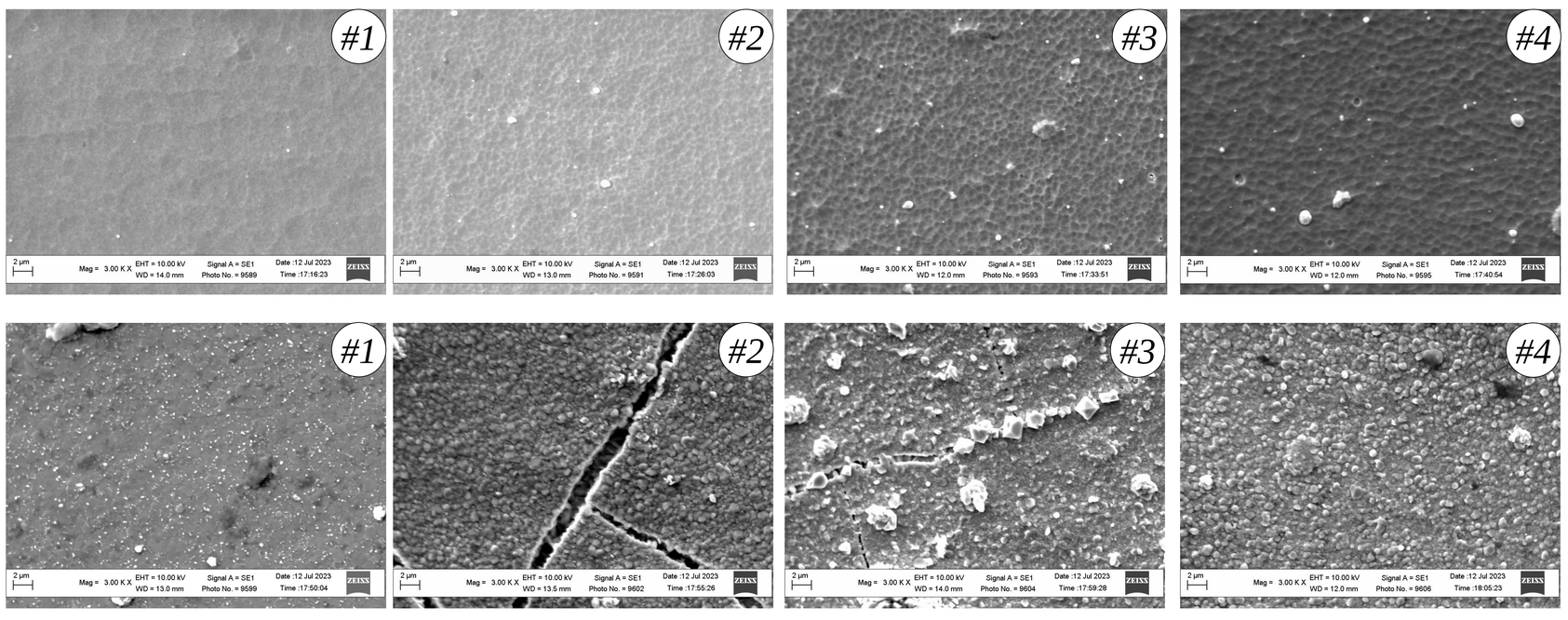


RESULTS

Table 1. Results of X-ray structural analysis of coatings of the Cr-N system

# specimen	Nitrogen pressure P, Pa	Bias voltage U, V	Thickness CrN, μm	Phases	Structural type	Lattice parameter a, nm	L, nm
1	2	150	16,6	CrN	NaCl (B1)	0,4173	38
2	0,2	120	6,9	CrN	NaCl (B1)	0,4166	19
				Cr	BCC (A2)		
3	2	150	4,1	CrN	NaCl (B1)	0,4180	21
				Cu - sublayer	HCC (A1)		
4	0,2	120	2,2	CrN	NaCl (B1)	0,4177	12
				Cr	BCC (A2)		
				Cu - sublayer	HCC (A1)		





Surface morphology of CrN coatings deposited on the stainless steel samples at different nitrogen pressure and bias voltage: upper row – initial state; bottom row – after long-term oxidation at 600°C in air

CONCLUSONS

- The analysis of the obtained results showed that the coating based on chromium nitride #1 has the best oxidation resistance and good adhesion, which allows it to be offered as a promising coating for current collectors of high-temperature fuel cells.

ACKNOWLEDGEMENT

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