(M, Mn or Fe)$_3$O$_4$ spinel for Advanced Electrical Conductive Layer for SOFC Stacks

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Introduction

Solid oxide fuel cells (SOFCs) are a very efficient energy generation technology, offering electrical efficiencies up to around 60-70%. However, SOFCs need to operate at high temperature and are therefore susceptible to cathode poisoning due to upstream chromium evaporation. To mitigate this issue, an alumina and an (Mn, Co)$_3$O$_4$-CeO spinel coating was developed at PNNL. The alumina coating provides an electrically nonconductive stable coating, and the spinel coating provides an electrically conductive and stable coating on the stack interconnects. However, the Mn-Co-O spinel contains Co, which is a relatively expensive material. Hence, if a cheaper element can be substituted, it could substantially reduce manufacturing cost. This paper summarizes recent efforts to replace Co with Ni or Cu and Mn with Fe.

Objective

Prevent Chromia species evaporation and maintain stable electrical conductive layer. Search for cost reducing pathway.

Issue and idea

The price of the Cobalt is $77 (USD)/Kg. In the case of manganese, the price is $2.12 (USD)/Kg. The copper price is $7.02 (USD)/Kg, and the nickel price is $12.41 (USD)/Kg. In the case of iron, the available data is only for the iron ore fines. The price of iron ore fines is $0.07 (USD)/Kg. The cost of each element is 9%, 16%, and 0.1% of cobalt price if we use copper, nickel, and iron respectively.

Results

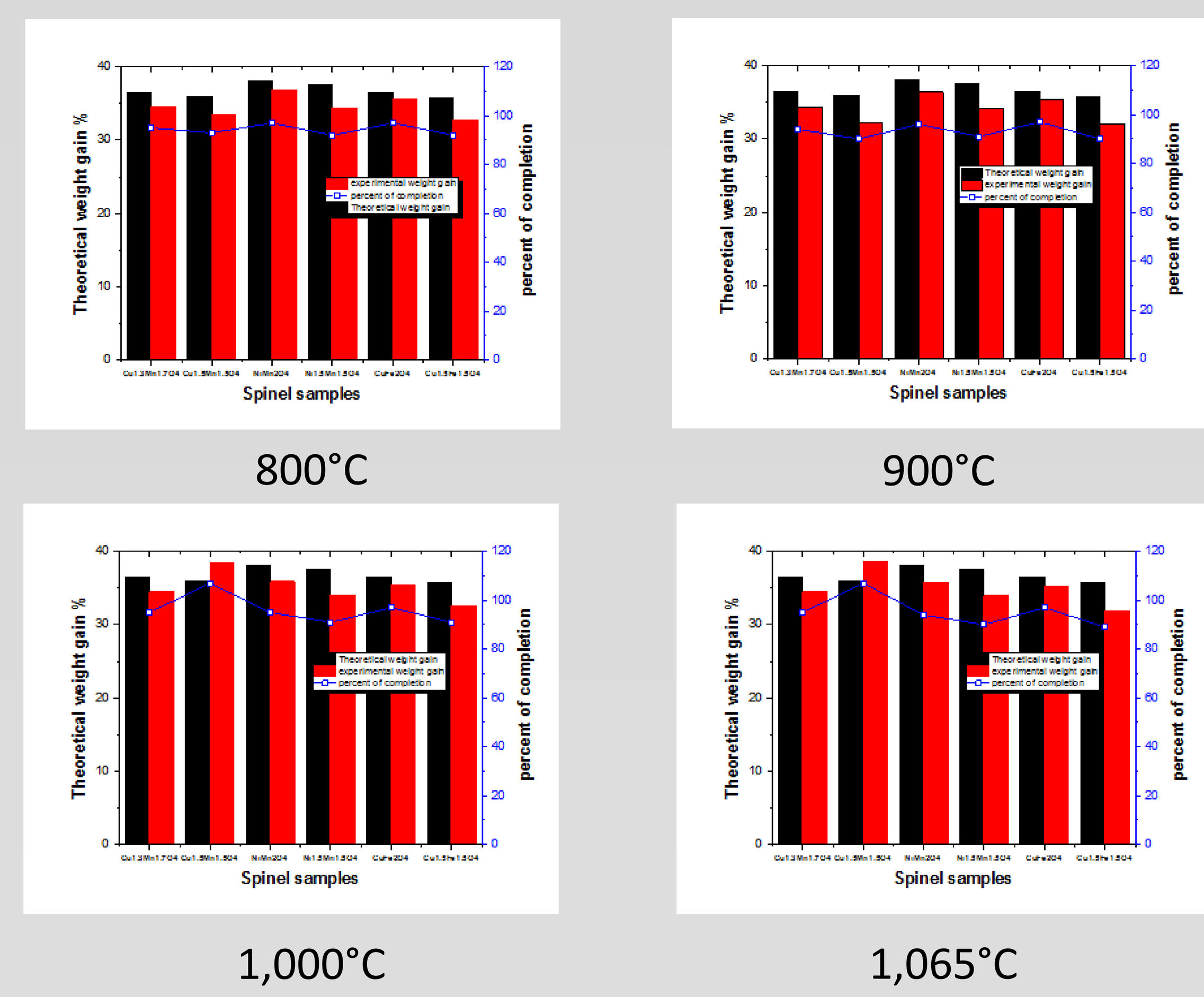
Unit: pm

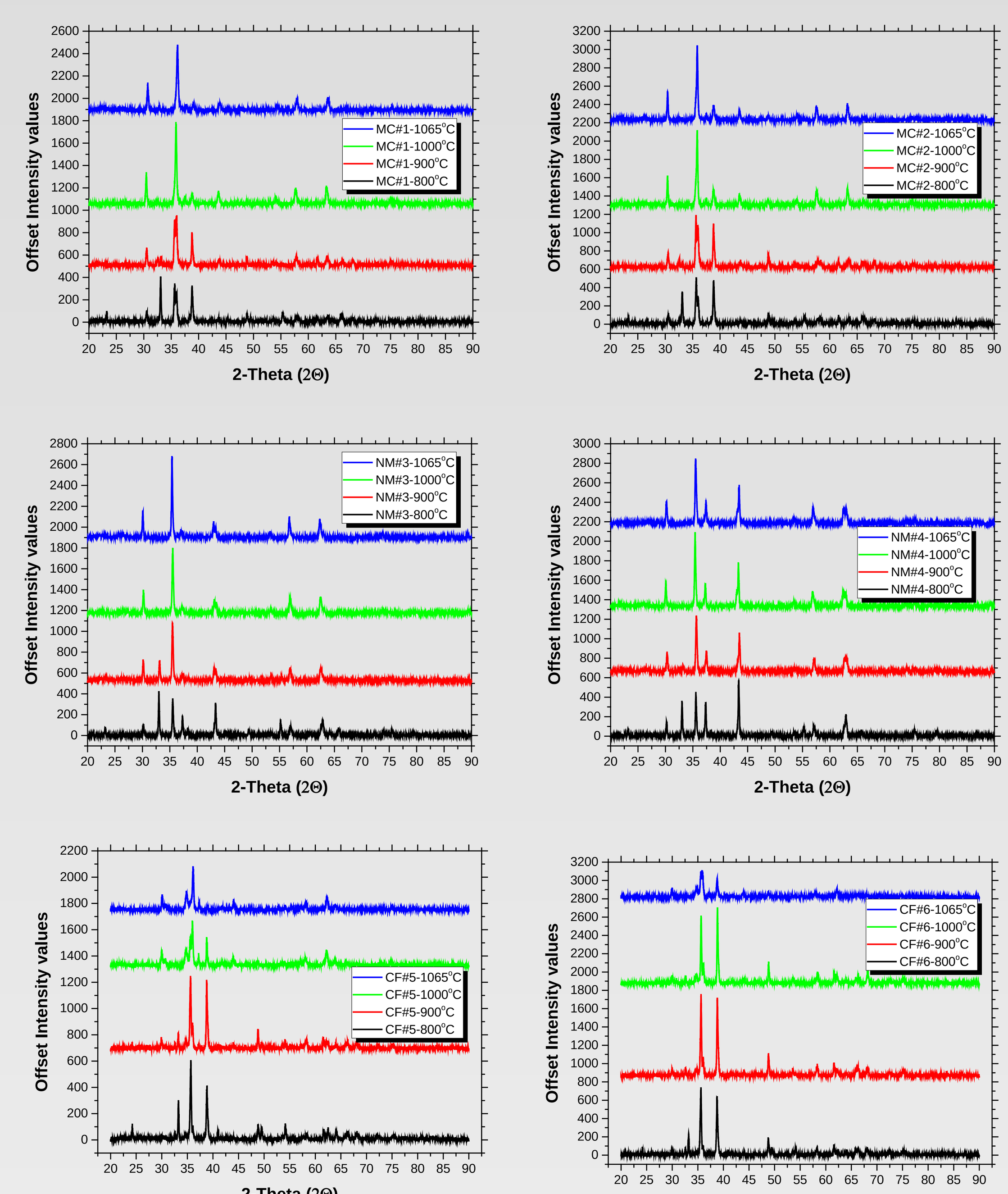
$A^{2+}B_2^{3+}O_4^{2-}$	Ionic Diameter	
Elements	A-atoms (tetrahedral)	B-atoms (Octahedral)
Co	72	68.5
Mn	80	72
Cu	71	68
Ni	69	70
Fe	77	69

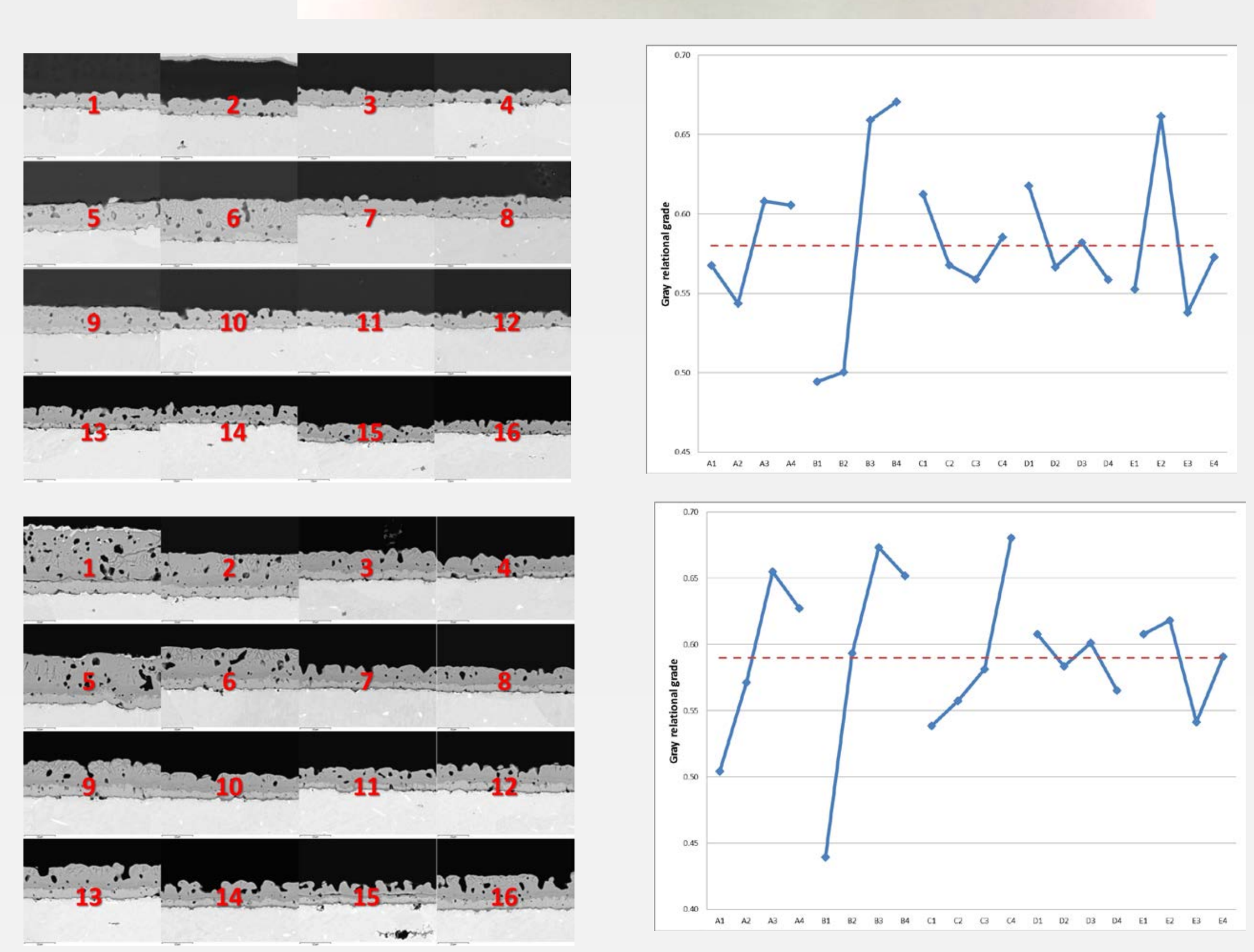
Candidate of spinel system

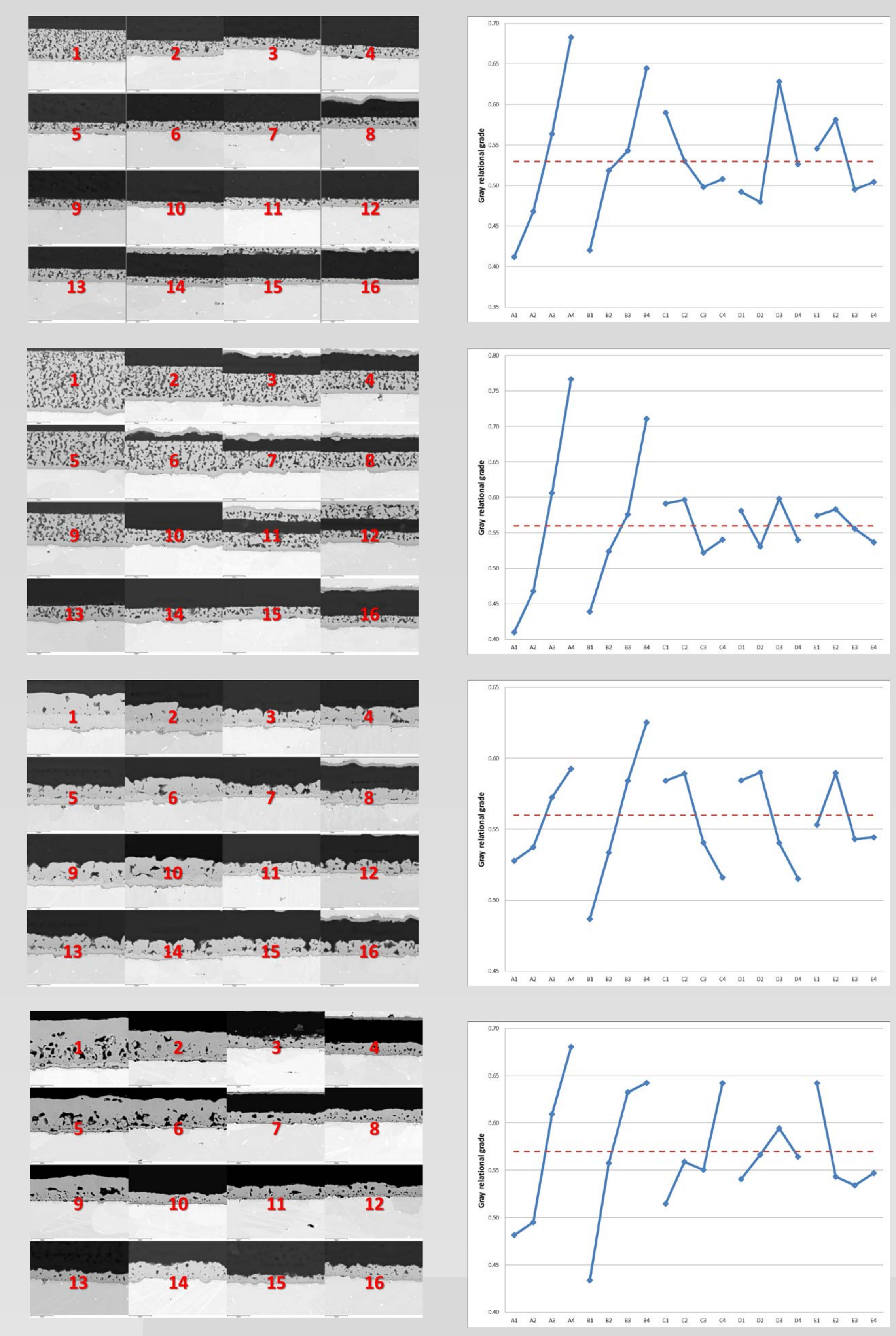
Spinel system	Possible composition	
(Cu, Mn)$_3$O$_4$	Cu$_{1.3}$Mn$_{1.7}$O$_4$	Cu$_{1.5}$Mn$_{1.5}$O$_4$
(Ni, Mn)$_3$O$_4$	NiMn$_2$O$_4$	Ni$_{1.5}$Mn$_{1.5}$O$_4$
(Cu, Fe)$_3$O$_4$	CuFe$_2$O$_4$	Cu$_{1.5}$Fe$_{1.5}$O$_4$

Direct Oxidation Method (DOM)









ABOUT

Pacific Northwest National Laboratory

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