Influence of Thermal Residual Strains on Bonding Strength and Fracture of Plasma Sprayed Ni/LDC Anode Coating on Ni Substrate

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In this paper, nano-structured LDC/NiO anode was deposited on porous Ni substrate by atmospheric plasma spraying (APS). The advantage of porous metallic supported fuel cell produced by APS process is to have a SOFC cell applied in the harsh environment with large cell area and effective production cost. However, through the spraying process, residual stresses are unavoidably developed in coatings due to the differences in thermal expansion coefficients, and different cooling conditions between the coating and the substrate.

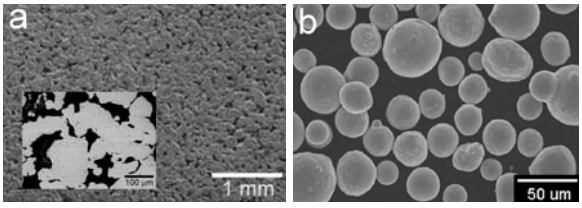

Fig. 1: (a) Porous Ni substrate, (b) NiO/LDC powder for plasma spraying

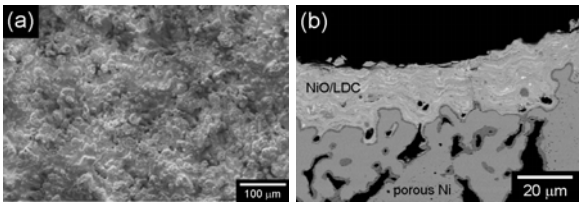

Fig. 2: (a) Morphology of NiO/LDC anode, (b) cross section view of coating

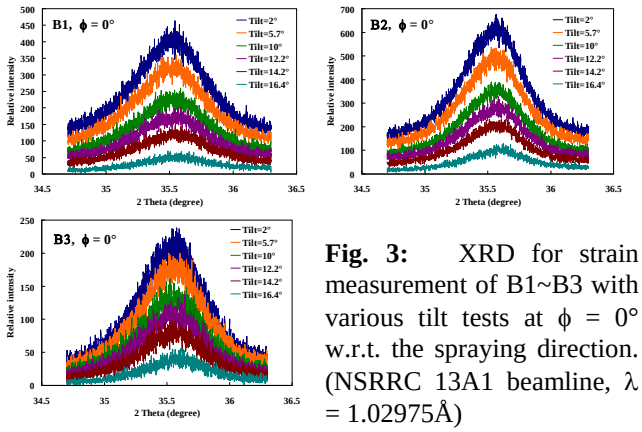

Fig. 3: XRD for strain measurement of B1~B3 with various tilt tests at ϕ = 0° w.r.t. the spraying direction. (NSRRC 13A1 beamline, λ = 1.02975Å)

Therefore, in this work, the results show that the compressive residual strain in the LDC/NiO anode decreases with the increase of Ni substrate temperature during the plasma spraying. Heating the substrate during APS coating process leads to the less mismatch of thermal expansion after cooling down of specimen. Moreover, the bonding strength between the anode and substrate decreases with the increasing compressive residual strain in the coating. The specimen with the highest bonding strength (40.1 MPa) and lowest compressive residual strain (0.36%) was obtained by heating the Ni substrate at 600℃ during spraying process. This is due to the compressive strain that would promote the tendency of coatings to delaminate or curve. The details are shown as below.

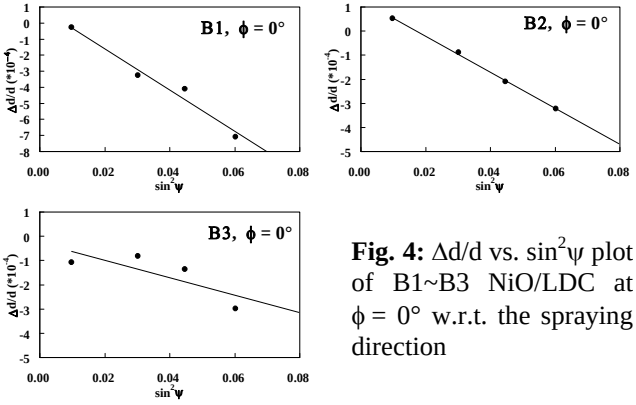

Fig. 4: $\Delta d/d$ vs. $\sin^2\psi$ plot of B1~B3 NiO/LDC at ϕ = 0° w.r.t. the spraying direction

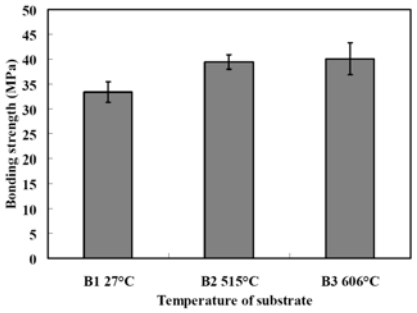

Fig. 5: The relationship between the bonding strength of coating to substrate and the temperature of substrate during spraying.

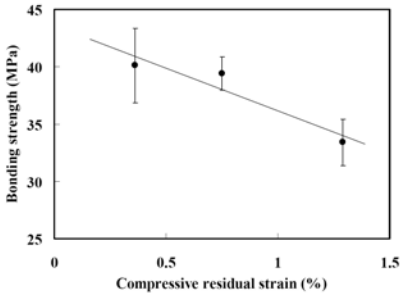

Fig. 6: The effect of compressive residual strain in the coating on the bonding strength between the coating and substrate.