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RESIDUAL STRESS AND MICROSTRUCTURE OF YSZ BUFFER LAYERS FOR YBCO COATED CONDUCTOR

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ABSTRACT
Y_2O_3–ZrO_2(YSZ) buffer layer was prepared by sol-gel technique. Residual stress and microstructure in the YSZ buffer layers were investigated as a function of temperature. Textured YSZ buffer layers were grown on biaxially textured-Ni (100) substrates using sol-gel method. YSZ coating on textured Ni substrate were annealed at 1150 °C under a flowing 4% H_2–Ar gas. Residual stress of buffer layers was analytically calculated. The surface morphologies and microstructure of all samples were characterized by using ESEM.
Keywords: Buffer layers, YSZ, Residual stress, sol-gel

1. INTRODUCTION
Although YBCO has the lowest Tc among the high temperature superconductors (HTS), due to its superior superconductivity properties above 77 K, recently YBCO is used to develop long, flexible tapes by using coated conductors that can carry high densities of current for superconducting application such as Magnetic Resonance Imaging (MRI), transformers, generators and underground transmission cables. One of the important parts of YBCO coated conductor is buffer layers. The purpose of buffer layer is to prevent diffusion of metal ions into YBCO, to reduce the lattice mismatch, and to retard oxidation of metallic substrate. Many buffer layers were studied for YBCO coated conductors by using various methods. These methods include pulsed laser deposition, molecular beam epitaxy, rf sputtering, sol-gel method. Among these methods the sol-gel methods have advantages which are continuous process at room temperature, low cost, better homogeneity, and simplicity.
The aims of the present work are: to grow crack free, pinhole-free, uniform YSZ buffer layer on Ni tape by using reel-to-reel continuous sol-gel dip coating system; to calculate residual stresses using analytical modelling for homogeneous Y_2O_3–ZrO_2 bufer layer on textured Ni substrate as a function of temperature.

2. EXPERIMENTAL PART
High purity (99.99 %) cold rolled nickel tapes, 0.05mm thick and 10mm wide, were cleaned by using acetone and methanol. They were annealed to obtain (100) cube texture at 1050°C for 30min under 4% H_2–Ar gas flow. Y_2O_3–ZrO_2 ($Zr_{0.98}Y_{0.02}O_{1.9}$) solution was prepared Yttrium acetate and Zirconium tetrabutoxide as explained in Ref. [3].
The θ/2θ, microstructure and texture analyses of Ni substrate were examined see Refs. [1]. Then Ni tapes were dipped into the YSZ solution and pulled through the vertical three-zone furnace. Furnace zone temperatures were between 450 and 500°C from bottom to the top. The film thickness was controlled by the withdrawal speed, the number of dipping and the dilute of solution. Then the

samples were annealed at 1150°C for 10min under 4% H_2–Ar gas flow.
Surface morphology, thickness and stoichiometry of insulation coating were observed by using the Environmental Scanning Electron Microscope (ESEM, electro scan model E-3 and Jeol-5910LV), and the Energy Dispersive Spectroscopy (EDS).

3. RESULTS AND DISCUSSION

The structure, microstructure and texture of Ni substrate were analyzed. Then YSZ films were coated on textured Ni substrate in a vertical three zone furnace and annealed at 1150°C for 10 min under 4% H_2–Ar gas flow. Schematic representation of YSZ/Ni buffer layer structure were shown in figure 1. Figure 2 depicts surface morphologies of YSZ buffer layer on Ni substrate. The microstructure shows a homogenous, dense and crack free YSZ film on Ni substrate. Moreover, the grain boundary were observed on the YSZ buffer layer a result of cold rolled Ni tapes.
Residual stress arise during the growing processs of baffer layers depending on temperature and film thickness. The structure of buffer layer is a thick plate with thin film. The stresses originate in buffer layer structure during the cooling process as explained in previous papers [1,2]. It can be assumed as quasi-static at any time.

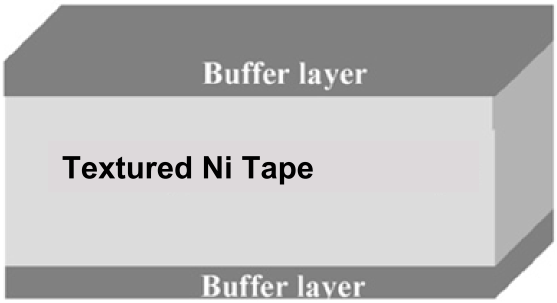

Figure 1. Schematics representation of YSZ/Ni buffer layer structure.

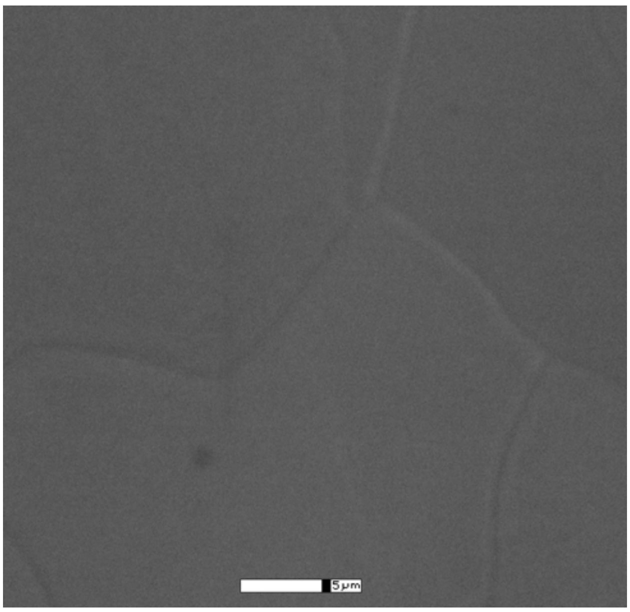

Figure 2. ESEM micrographs of YSZ/Ni buffer layer structure. The white scale bar is 5 μm.

Ni substrate and YSZ buffer layer properties are given in Table 1. The expression of residual stress are given below [5]

$$\sigma_{yy} = \sigma_{xy} = \sigma_{xz} = \sigma_{yz} = 0$$
$$\sigma_{xx} = \sigma_{zz} = -\frac{E\alpha}{1-\nu}\Delta T + c_2 y + c_1 \qquad (1)$$

The residual stress components in the mid of structure are given in Figure 3.

Table 1. Material properties of the buffer layer structure [3,4]

Material properties	YSZ	Ni
E (GPa)	53	221
v	0.25	0.33
α (10^{-6}/K)	7.2	13.9

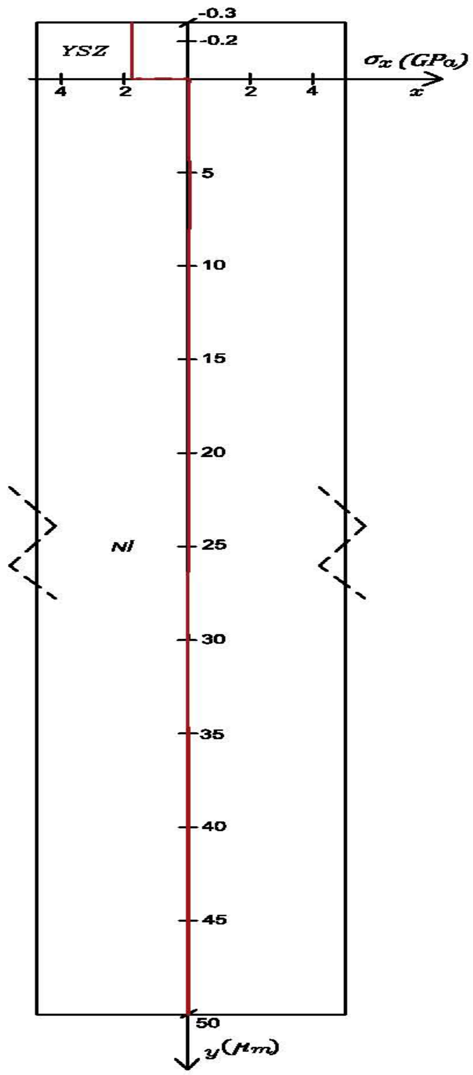

Figure 3. Residual stresses in buffer layer structures in GPa

4. CONCLUSIONS

Yttrium-Stabilized Zirconia (YSZ) buffer layer was coated on textured Nı substrate by using sol-gel dip coating system. The residual stress analysis of YSZ/Ni buffer layer structure was studied as a function of temperature because of cooling from annealing to room temperature.

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5. REFERENCES

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