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EFFECT OF TEMEPERATURE ON STRESS OF Y_2O_3-ZrO_2 INSULATION COATING ON STAINLES STEEL TAPE

A. Donmez, O. Bulut, T. Baytak, M. Tosun, S. Ataoglu, C. Ipek
Faculty of Civil Engineering, Istanbul Technical University,
Maslak, 34469, Istanbul, Turkey

O. Cakiroglu
Hasan Ali Yucel Education Faculty, Istanbul University,
Beyazit, 34452 Istanbul, Turkey

ABSTRACT
Y_2O_3-ZrO_2 insulation coating are coated on long length stainless steel (SS) tapes by using reel-to-reel sol-gel continuous dipping process using vertical three-zone furnace. Furnace zone temperatures are between 450 and 650℃ from bottom to top. Residual stress and microstructure in the YSZ insulation coating were investigated as a function of temperature. Residual stress of insulation coating was analytically calculated. It is found that the maximum stress values are obtained as 1.59 GPa compression on coating. The surface morphologies and microstructure of all samples were characterized by using ESEM.
Keywords: Electrical insulation, YSZ, Residual stress, sol-gel

1. INTRODUCTION
The sol-gel method is one of the most promising technique for many area including optoelectronic, optical memory, high temperature superconductor, ferroelectrics, dielectrics, and so on because of some advantages such as continuous process at room temperature, low temperature applications, simplicity, better homogeneity and cost effectiveness. However, sol-gel coating has some failures which depend on processing parameters, heat treatment and annealing conditions [1].
The aims of the present work are: to fabricate *Y_2O_3-ZrO_2* (YSZ) insulation coating on SS tape by using reel-to-reel continuous sol-gel dip coating system; to calculate residual stresses using analytical modelling for long–length YSZ insulation coating on SS tape as a function of temperature.

2. EXPERIMENTAL PART
Stainless steel (SS-304) tapes were cleaned by using pure acetone and methanol. 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. [2]. Then SS tapes were dipped into the YSZ solution and pulled through the vertical three-zone furnace. Furnace zone temperatures were between 450 and 650°C from bottom to the top. The film thickness was controlled by the withdrawal speed, the number of dipping and the dilute of solution.
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).

3. RESULTS AND DISCUSSION
YSZ insulation coating were produced on SS tape in a vertical three zone furnace. Schematic representation of YSZ/SS insulation coating structure was shown in figure 1. Figure 2 depicts surface morphologies of YSZ insulation coating on SS tape. The microstructure shows cracks and pinholes which occur from solution preparation and coating process. This crack structure improves the

adhession of final protecting epoxy layer.

The ressidual stresses originate in insulation coating structure during the cooling process as explained in previous papers [3,4]. It arises during the growing processs of YSZ insulation coating depends on temperature. The residual stress for YSZ insulating coating on SS tape is calculated the same procedure as in [1-4].

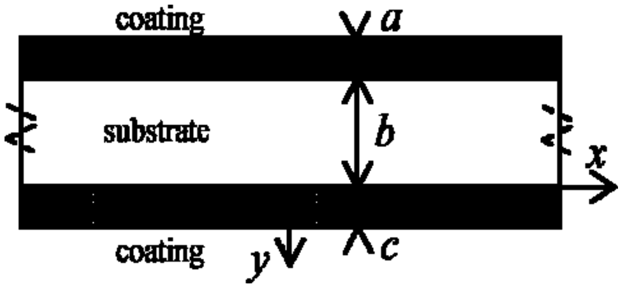

Figure 1. Schematics representation of YSZ/SS/YSZ insulation coating structure

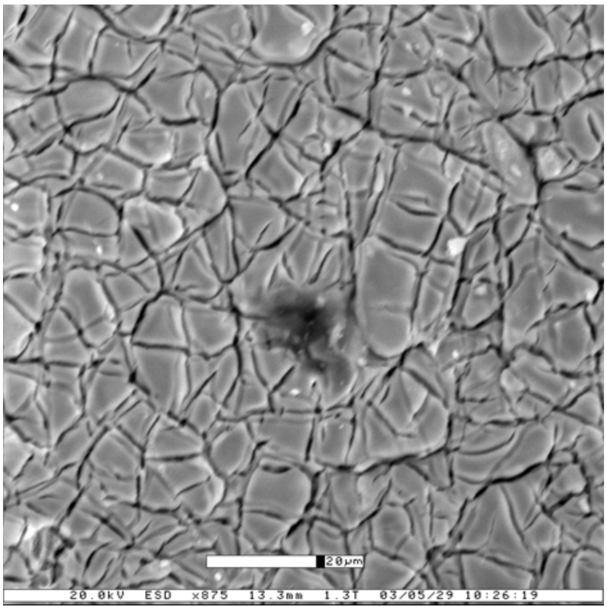

Figure 2. ESEM micrographs of YSZ/SS buffer layer structure. The white scale bar is 20 µm.

SS tape and YSZ insulation coating properties are given in Table 1. The expressions of residual stress are given below [5]

$$\sigma_{yy} = \sigma_{xy} = \sigma_{xz} = \sigma_{yz} = 0$$

$$\sigma_{xx} = \sigma_{zz} = -\frac{E\alpha}{1-\nu}\Delta T + c_2 y + c_1$$

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

Table 1. Material properties of the buffer layer structure [1, 2]

Material properties	YSZ	SS-304
E (GPa)	53	200
v	0.25	0.3
α (10^{-6}/K)	7.2	17

4. CONCLUSIONS

Yttrium-Stabilized Zirconia (YSZ) insulation coating was fabricated on SS-304 tape by using sol-gel continuous dip coating system. The residual stress analysis of YSZ insulation coating on SS tape was studied as a function of temperature. It is found that variation of residual stress component is constant in substrate (1.01 GPa) and coating (-1.59 GPa).

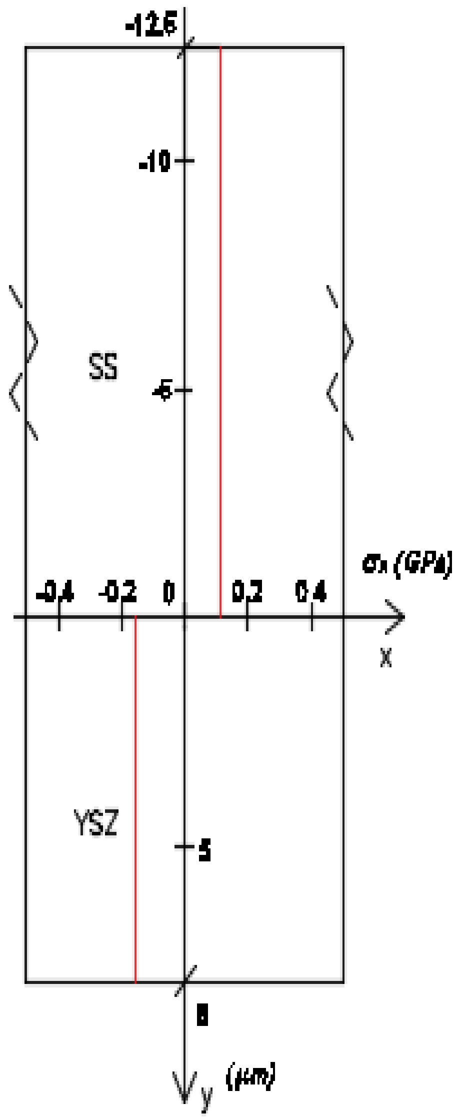

Figure 3. Schematics for the calculation of residual stresses in SS tape and YSZ insulation coating structures with stress distribution in GPa.

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5. REFERENCES

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