FunGlass

Centre for Functional and Surface Functionalized Glass

Alexander Dubček University of Trenčín

SOLID STATE SYNTHESIS AND CHARACTERIZATION OF $La_2Ce_2O_7$ POWDER AS A CANDIDATE MATERIAL FOR THERMAL BARRIER COATINGS

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INTRODUCTION

For the thermal barrier coatings (TBCs) system during service, structural instability including phase transformation and decomposition is a key factor that restricts its comprehensive properties. Lanthanum cerium oxide, $La_2Ce_2O_7$ (LC), has attracted increasing interest as a promising material for TBC because of its high phase stability and potential capability to be operated above 1250°C [1]. Moreover, LC exhibits lower thermal conductivity and higher CTE than the conventional YSZ material [2]. However, TBCs based on LC/YSZ showed a better thermal cycling behavior than single LC or YSZ coating [3]. Therefore, a coating structure and composition should be rationally designed to utilize the advantages of LC. In this work, LC powder was synthesized by solid-state reaction and investigated as a material for TBC applications. The mechanical properties of hot-pressed LC/50YSZ bulk samples are also presented.

OBJECTIVES & METHODS

SOLID-STATE SYNTHESIS of LC powder: La_2O_3 + CeO_2 → ball-milling in IPA

HEAT TREATMENT of LC powder: 1100 – 1400 °C for 6 hours

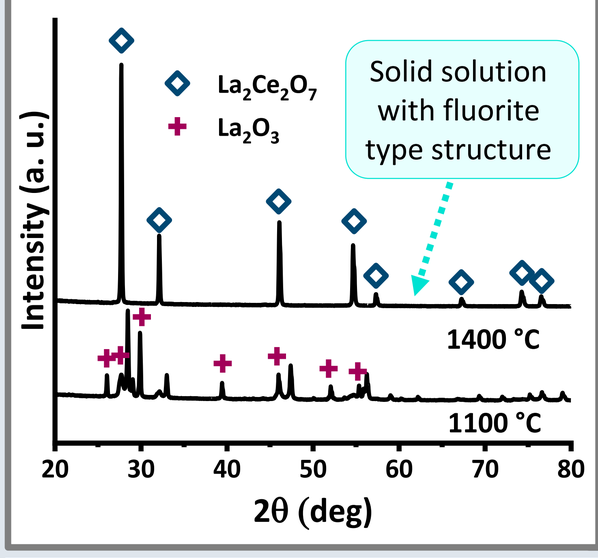
CHARACTERIZATION of LC powder: SEM/EDS, XRD, DSC/TGA, Raman

HOT PRESSING of LC/50YSZ (wt.%) powders: 1350 °C/1h/30MPa/vacuum

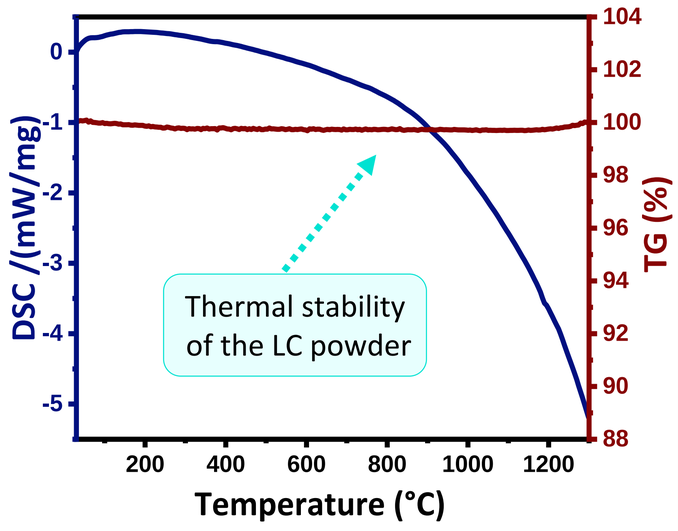
CHARACTERIZATION of LC/50YSZ bulk sample: density, HV (5N, 10s), K_{IC}

RESULTS

XRD results



DSC/TGA analysis

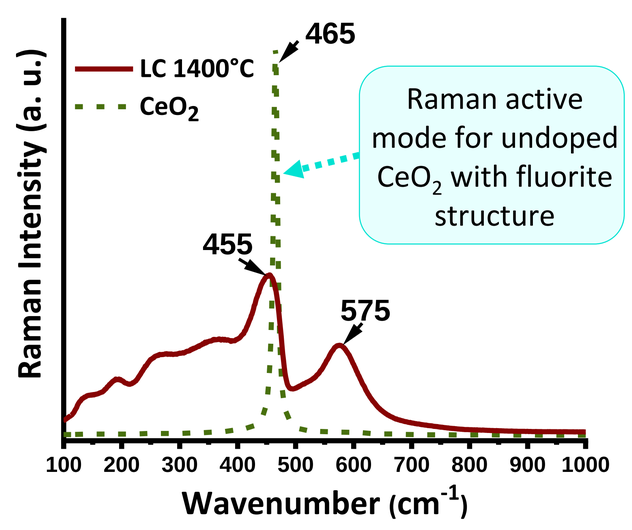


Raman Spectroscopy

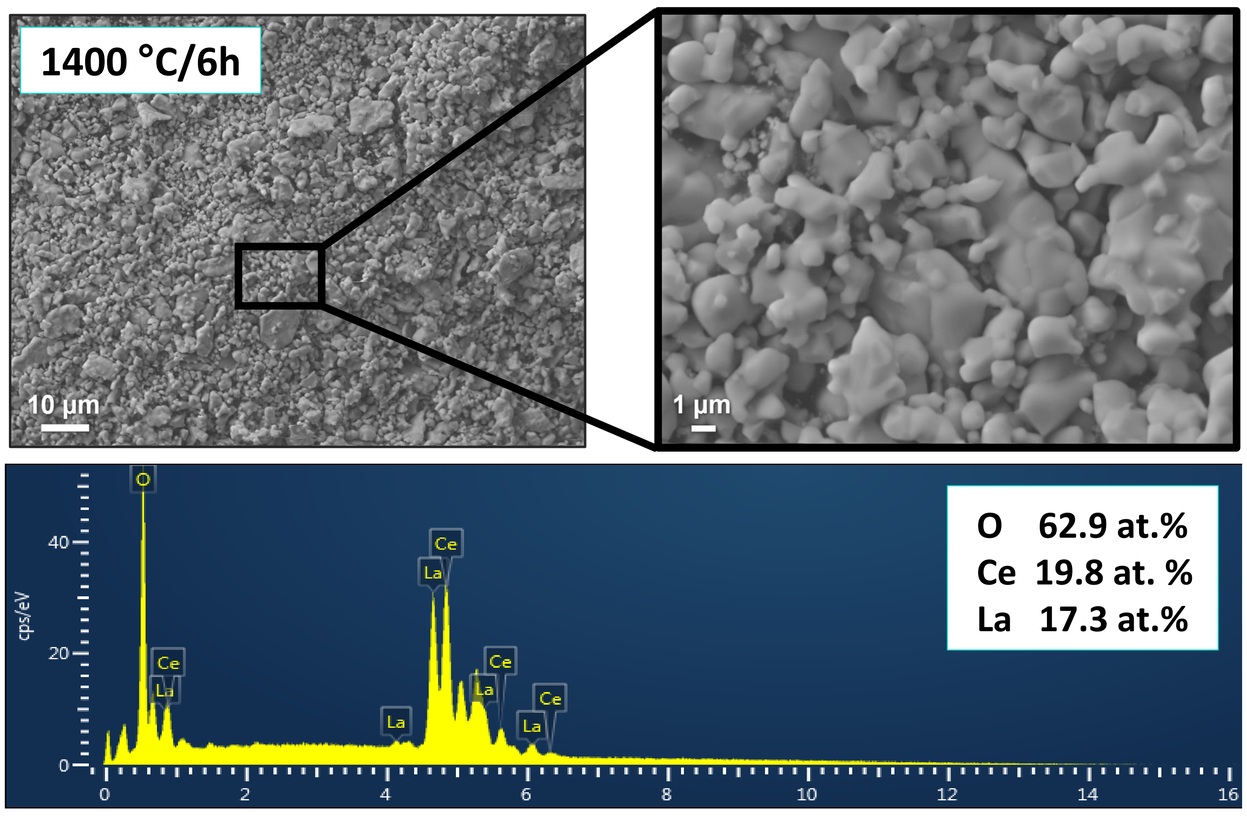
Band at ~455 cm^{-1} – F2g vibration of Ce-8O bond of fluorite type lattice in pure CeO_2

Band at ~575 cm^{-1} – oxygen vacancies due to the charge compensation mechanism

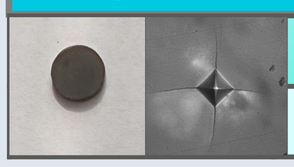
Weak bands at low frequencies – forbidden acoustic modes caused by defects in the structure [4]



SEM/EDS characterization



Properties of hot-pressed LC/50YSZ bulk sample



Rel. density (%)	HV (GPa)	K_{IC} (MPa.$m^{1/2}$)
98.64	11.2 ± 0.87	2.14 ± 0.1

CONCLUSIONS

- **The fluorite structure of the LC powder after annealing at 1400 °C was confirmed by XRD showing intensive $La_2Ce_2O_7$ peaks. No additional peaks belonging to La_2O_3 were observed, confirming the formation of solid solution of La_2O_3 in CeO_2.**
- **SEM of the prepared powder revealed agglomerated structure consisting of finely and uniformly distributed grains with size up to 10µm. EDS analysis indicates chemical composition of the prepared LC powder similar to the stoichiometric ratio of the $La_2Ce_2O_7$.**
- **Neither obvious mass change nor visible energy change were observed from the DSC curve at the tested temperature range, indicating high phase stability of the LC powder and its suitability for TBC applications.**

[1] Dehkharghani, A. M. F. et al. (2020). Crystal Structure and Lattice Parameter Investigation of La^{3+} Substituted CeO_2 in $La_xCe_{1-x}O_{2-X/2}$ Synthesized by Solid-State Method. *Advanced Ceramics Progress, 6*(1), 43–48. **[2]** Zhang, H. et al. (2019). Thermal and mechanical properties of Ta2O5 doped La2Ce2O7 thermal barrier coatings prepared by atmospheric plasma spraying. *Journal of the European Ceramic Society*, 39(7), 2379–2388. **[3]** Ma, W. et al. (2008). Novel thermal barrier coatings based on $La_2Ce_2O_7$/8YSZ double-ceramic-layer systems deposited by electron beam physical vapor deposition. *Surface and Coatings Technology*, 202(12), 2704–2708. **[4]** Zhang, H. et al. (2019). Mechanical properties and thermal cycling behavior of Ta_2O_5 doped $La_2Ce_2O_7$ thermal barrier coatings prepared by atmospheric plasma spraying. *Journal of Alloys and Compounds*, 785, 1068–1076.

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