



IJRASET

International Journal For Research in
Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 Issue: IX Month of publication: September 2020

DOI: <https://doi.org/10.22214/ijraset.2020.31459>

www.ijraset.com

Call:  08813907089

E-mail ID: ijraset@gmail.com

Effect of Oxidation and Mechanical Properties of Low Thermal Conductivity Material Coated on IN718 by Thermal Barrier Coating

K Mugesh¹, Dr. S. Sankarapandian²

^{1,2}Mechanical Engineering, Alagappa Chettiar Government College of Engineering & Technology.

Abstract: In this study the mechanical properties of air plasma sprayed YSZ, AlCrO_3 +YSZ AlCrO_3 +50% YSZ thermal barrier coating (TBC) coatings were evaluated and also compared with each other. The synthesized AlCrO_3 is blended to commercial YSZ on ratio of bare and 1:1wt, 1:2 wt, were coated on IN718. The thermal barrier coatings on IN718 material were characterized by mechanical properties and oxidation behaviour was studied. The AlCrO_3 is added as binding element to YSZ to improve the mechanical properties of TBC. The results of mechanical properties and oxidation graph are incorporated in this report. This work clears new pathways to achieved without bond coat to good adhesive strength and resist thermal expansion for TBCs.

Keywords: Thermal barrier coating, YSZ, tensile test, oxidation, AlCrO_3 .

I. INTRODUCTION

Thermal barrier coating (TBCs) are generally utilized in the gas turbine to improve its strength and vitality proficiency. Yttria stabilized zirconia (YSZ) ceramic as the top coat material has been utilized for a considerable length of time because of its attractive properties including high fracture toughness, low thermal conductivity and high thermal expansion co-efficient. Be that as it may, the strength and unwavering quality of air plasma spray (APS) YSZ TBCs are confined for the propensity of break and untimely spallation because of the arrangement and development of thermally grown oxide (TGO) in administration. Oxidation is additionally another significant explanation behind the YSZ TBC disappointment .the thermally grown oxide (TGO) framed between the top coat and bond coat make a crisscross in warm extension of coating and the spallation of coating begins. In the interim, YSZ coatings are additionally found on gas turbines, utilized as thermal barrier coating (TBCs). With respect to their testimony procedure, different techniques have been utilized, for example, air plasma spray (APS), electron beam-physical vapour deposition (EB-PVD), sol-gel, vaporized statement. APS innovation is broadly utilized in modern scale to store YSZ coatings in light of high testimony rate, prudent proficiency and capacity to create thick coatings with high glue quality. Notwithstanding, a high porosity (around 5–8%) in fired coatings utilizing ordinary APS is practically unavoidable. High porosity in YSZ coatings is useful to thermal protection, for it normally lessens the successful thermal conductivity of coatings, while, it is harmful for hostile to oxidation reason. From one viewpoint, higher porosity implies progressively destructive species infiltrating into the coatings, therefore denser ceramics coatings display higher consumption obstruction. On the other hand, YSZ coatings may be secured by liquid salt when filled in as TBCs in the hot area of a motor. The infiltration of these contaminants through the permeable and small scale broke coatings may assault the hidden super composite by hot consumption instruments. Anyway this standard material has a constrained temperature ability because of quickened sintering and stage changes at high temperatures. As a rule, TBC material prevent to satisfy the vast majority of the accompanying necessities, for example, a steady stage, low thermal conductivity ($9 \times 10^{-6} \text{ K}^{-1}$), low sintering rate, and high break durability. An overall exertion has been attempted to recognize new possibility for a TBC application. In our gathering, we have arranged some antacid earth perovskites, for example, SrCeO_3 and SrHfO_3 and considered their appropriateness to the TBC materials. Against this foundation, we center around AlCrO_3 as the new TBC materials. AlCrO_3 is typical inter oxide in the Al_2O_3 , Cr_2O_3 Thermal and mechanical properties are barely detailed.

II. MOLTEN SALT SYNTHESIS

Molten salt synthesis, one of the best conventional methods of preparing ceramic powders, involves the use of molten salt as the medium for preparing complex oxides from their constituent materials. The AlCrO_3 was synthesized by molten salt synthesis method. The A mixture of reactant and salt powders is heated at temperatures above the melting point of the salt. The reactants interact under the presence of the molten salt. After a predetermined heating stage, the product mass is cooled, and washed with a solvent (mainly water) to remove the salt. The product powder is obtained after drying. The flow chart of molten salt synthesis is shown fig-1

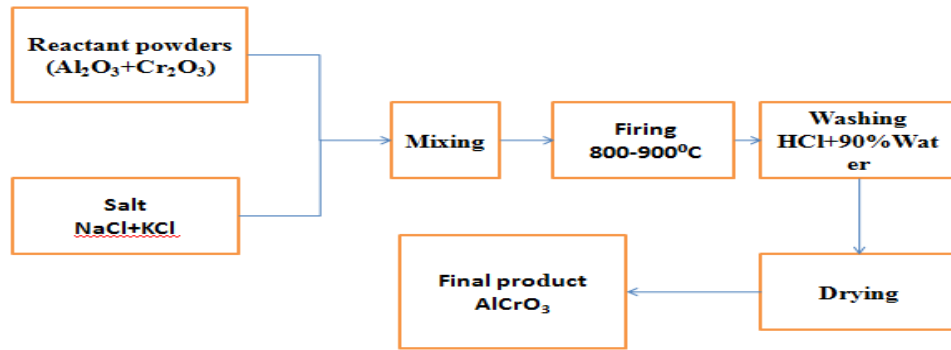


Fig.1 molten salt synthesis flow chart

III.FABRICATION OF COATING

Inconel 718 superalloy of Ni-19Cr-18.5Fe-5.1Nb-3Mo-0.9Ti0.5Al (wt%) substrate was cut for wire cut EDM. To achieve high coating adhesion and good mechanical bonding to the substrate, the surface of the substrate should be roughened Prior to spraying, the substrates were degreased by acetone and then grit blasted with alumina particles. During the APS process, the molten particles are quenched by impacting to the substrate giving rise to residual thermal misfit stresses in the coating and substrate. To reduce these stresses, the substrate preheating should be carried out Therefore, just before depositing the coatings, the substrates were preheated up to about 200°C. The mixture of AlCrO₃+ YSZ were used as feedstock for the deposition of coat material. The final thicknesses were approximately 100µm to 300µm for the top coat, respectively.

IV.RESULT AND DISCUSSION

A. Tensile Test

The tensile stress testing was carried out UTM. The test was performed in a universal testing machine (TiniusOlsen H20K) with a capacity of 20KN. The standard specimen for ASTM E8 is 165x20x3 mm Tensile test. In order to check the tensile strength of coating, Tensile tests were conducted in accordance with ASTM E8 for coated samples. Shown below is tensile test coated sample fig.2 and coating sample increases tensile stress show fig.3, ultimate force fig .4



Fig.2 coating sample tensile stress

TABLE I

Ratio	Ultimate Stress (MPA)	Ultimate Force (KN)	Break Distance (mm)
Bare YSZ	265.24	12.12	10.05
1:1	287.35	13.25	11.07
1:2	287.03	12.71	10.85

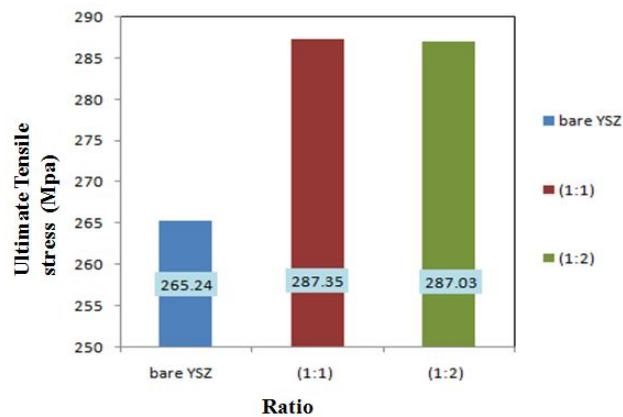


Fig .3 increases tensile stress

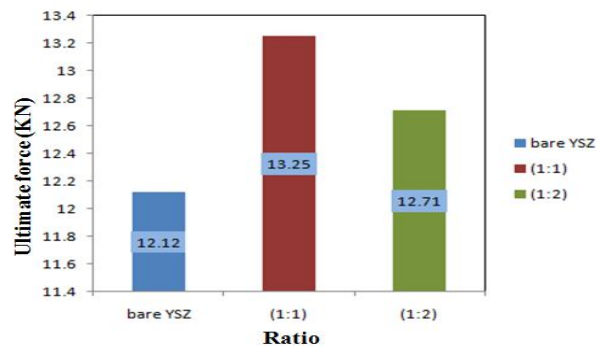


Fig.4 ultimate force

B. Microhardness Test

The hardness benefits of coating are acquired on Vickers smaller scale hardness mechanical assembly utilized. The load applied on the coating by indenter is 100g for 5sec. the hardness estimation of exposed YSZ coating is 550HV, AlCrO₃+YSZ (1:1) coating is 480HV and AlCrO₃+YSZ (1:2) is 516HV. the hardness estimation of uncoated compare coating is moderately high think about of other two coating. This decrease of hardness benefit of coating is expected to AlCrO₃. The figure No.5 chart of hardness benefit of coating.

TABLE III

Ratio	Hardness Value (HV)
Bare YSZ	550
1:1	480
1:2	516

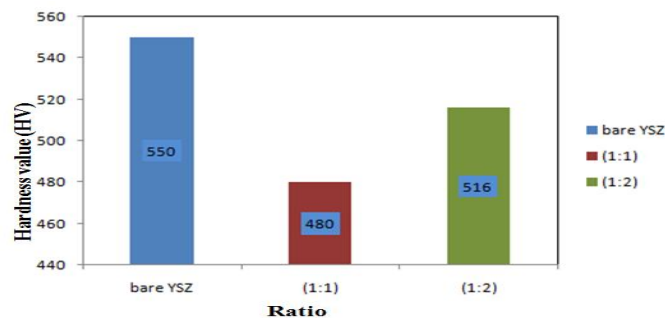


Fig.5 chart of hardness

C. Oxidation Kinetic

The oxidation kinetic tests were conducted on all the three pellets of bare YSZ, AlCrO_3 +YSZ and AlCrO_3 +%50 YSZ at 900 °C for the duration of 25 hr. The oxidation kinetic rate of weight gains were recorded on each sample by measuring the weight change using physical semimicro balance. The figure.6 shown below is oxidation of pellets sample. The figure.7 show below is oxidation graph.

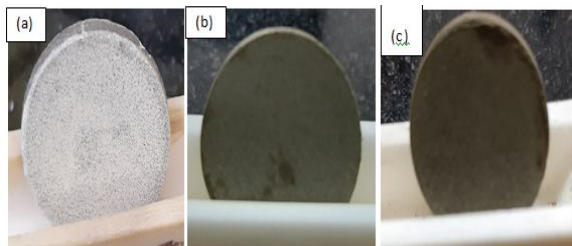


Fig.6(a. bare YSZ, b. AlCrO_3 + YSZ c. AlCrO_3 + 50% YSZ)

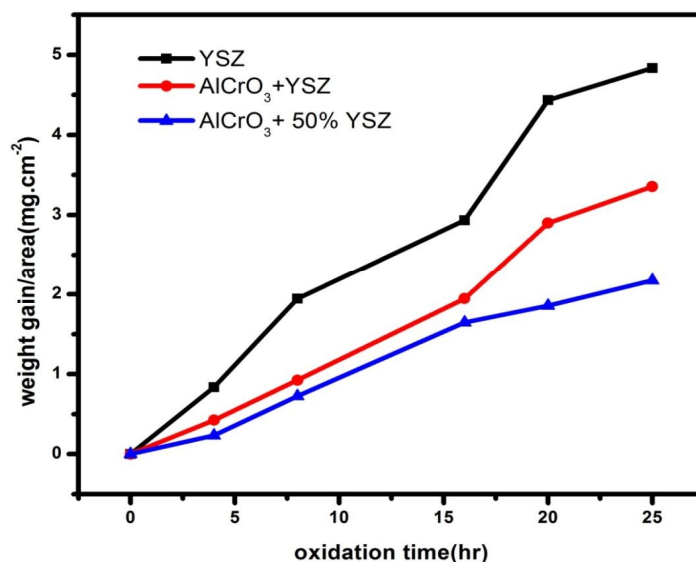


Fig.7 oxidation graph

V. CONCLUSIONS

In this paper, AlCrO_3 +YSZ coatings were deposited using atmosphere plasma spraying. The effects of AlCrO_3 addition on the mechanical properties of the plasma sprayed AlCrO_3 +YSZ composite coatings were investigated. The main conclusions are summarized as follows

- A. The hardness value of blend coating is lower than commercial bare YSZ coating due to ductile properties.
- B. The tensile properties of blended coating is increased compare to commercial bare YSZ coating.
- C. The bare YSZ demonstrate higher oxidation rate in compared with AlCrO_3 +YSZ in oxidation.

This work clears new pathways for the exploration with non bond materials for TBCs.

VI. ACKNOWLEDGMENT

I am grateful to my research guide Dr.S.SANKARAPANDIAN.,Ph.D. Assistant Professor of Mechanical Engineering for his valuable suggestions, constant suggestions and guidance for this work. I would like to record our deep sense of gratitude to research scholar Anup kuchipudi, Sundar viknesh, Mukiri soban babu.

REFERENCES

- [1] Ken Kurosaki, Takanori Tanaka, Takuji Maekawa, Shinsuke Yamanaka *Journal of Alloys and Compounds* 395 (2005) 318–32.
- [2] Shuwan Cui, Yonghua Shi, Kun Sun, Shengyong Gu *Materials Science & Engineering* S0921-5093(17)31369-2
- [3] ASTM International. Designation: E8/ E8M-16a Standard test methods for tension testing of metallic materials. West Conshohocken, PA: ASTM International; 2016
- [4] ASTM International. Designation: E290-14 Standard test methods for bend testing of material for ductility. West Conshohocken, PA: ASTM International; 2014.
- [5] Ke He, JingJie Chen, WeiXiangWeng, CaiCai Li, Qiang Li *Vacuum* S0042-207X(17)31772-4
- [6] Rujie He, Zhaoliang Qu, Yongmao Pei, Daining Fang *Materials Letters* 209 (2017) 5–7
- [7] S.M. Hashemi, N. Parvin, Z. Vafaei *Ceramics International* S0272-8842(18)33344
- [8] Kang Ma a, HuiminXie, Jianguo Zhu, HuaixiWang *Surface & Coatings Technology* xxx (2014) xxx–xxx
- [9] Haynes JA, Ferber MK, Porter WD. Thermal cycling behavior of plasma-sprayed thermal barrier coatings with various MCrAlX bond coats. *Journal of Thermal Spray Technology*. 2000; 9: 38-48.
- [10] Sfar K, Aktaa J, Munz D. Numerical investigation of residual stress fields and crack behavior in TBC systems. *Materials Science and Engineering: A*. 2002; 333: 351-360.
- [11] Yang L, Yang F, Long Y, Zhao Y, Xiong X, Zhao X, Xiao P. Evolution of residual stress in air plasma sprayed yttria stabilized zirconia thermal barrier coatings after isothermal treatment. *Surface and Coatings Technology*. 2014; 251: 98-105.
- [12] Pujol G, Ansart F, Bonino J-P, Malié A, Hamadi S. Step-by-step investigation of degradation mechanisms induced by CMAS attack on YSZ materials for TBC applications. *Surface and Coatings Technology*. 2013; 237: 71-78.
- [13] Thompson JA, Clyne TW. The effect of heat treatment on the stiffness of zirconia top coats in plasma-sprayed TBCs. *Acta Materialia*. 2001; 49: 1565-1575.
- [14] Abubakar AA, Akhtar SS, Arif AFM. Phase field modeling of V2O5 hot corrosion kinetics in thermal barrier coatings. *Computational Materials Science*. 2015; 99: 105-116.
- [15] Kulkarni A, Vaidya A, Golland A, Sampath S, Herman H. Processing effects on porosity- property correlations in plasma sprayed yttria-stabilized zirconia coatings. *Materials and Engineering A*. 2003; 359: 100-111.
- [16] Zhang D, Gong S, Xu H, Wu Z. Effect of bond coat surface roughness on the thermal cyclic behavior of thermal barrier coatings. *Surface & Coatings Technology*. 2006; 201: 649-653.
- [17] Movchan BA, Yakovchuk YK. Graded thermal barrier coatings, deposited by EBPVD. *Surface & Coatings Technology* 2004; 188-189: 85-92.
- [18] Wu LT, Wu RT, Zhao X, Xiao P. Microstructure parameters affecting interfacial adhesion of thermal barrier coatings by the EB-PVD method. *Materials Science & Engineering* :2014; 594: 193-202.
- [19] Basu SN, Ye G, Gevelber M, Wroblewski D. Microcrack formation in plasma sprayed thermal barrier coatings. *International Journal of Refractory Metals & Hard Materials*. 2005; 23: 335-343.
- [20] Bengtsson P, Johansson TJ. Characterization of microstructural defects in plasma sprayed thermal barrier coatings. *Journal of Thermal Spray Technology*. 1995; 4:245-251.
- [21] Chen WR, Wu X, Dudzinski D, Patnaik PC. Modification of oxide layer in plasma sprayed thermal barrier coatings. *Surface & Coatings Technology*. 2006; 200:5863-5868.
- [22] Tang F, Schoenung JM. Evolution of Young's modulus of air plasma sprayed yttria-stabilized zirconia in thermally cycled thermal barrier coatings. *Scripta Materialia*. 2006; 54: 1587-1592.
- [23] Basu D, Funke C, Steinbrech RW. Effect of heat treatment on elastic properties of separated thermal barrier coatings. *Journal of Materials Research*. 1999; 14: 4643-4650.
- [24] Limargaa AM, Widjajab TS, Yip TH. Mechanical properties and oxidation resistance of plasma-sprayed multilayered Al₂O₃/ZrO₂ thermal barrier coatings. *Surface & Coatings Technology*. 2005; 197: 93-102.
- [25] Guo HB, Kuroda S, Murakami H. Segmented thermal barrier coatings produced by atmospheric plasma spraying hollow powders. *Thin Solid Films*. 2006; 506-507:136-139.
- [26] Chen X, Gu L, Zou B, Wang Y, Cao X. New functionally graded thermal barrier coating system based on LaMgAl₁₁O₁₉/YSZ prepared by air plasma spraying. *Surface & Coatings Technology*. 2012; 206: 2265-2274.
- [27] Préaucht B, Drawin S. Properties of PECVD-deposited thermal barrier coatings. *Surface & Coatings Technology*. 2001; 142-44: 835-842.
- [28] Vyas JD, Choy K-L. Structural characterisation of thermal barrier coatings deposited using electrostatic spray assisted vapour deposition method. *Materials Science and Engineering: A*. 2000; 277: 206-212.
- [29] Gell M, Xie L, Ma X, Jordan EH, Padture NP. Highly durable thermal barrier coatings made by the solution precursor plasma spray process. *Surface and Coating Technology*. 2004; 177-178: 97-102.
- [30] Jadhav A, Padture NP, Wu F, Jordan EH, Gell M. Thick ceramic thermal barrier coatings with high durability deposited using solution-precursor plasma spray. *Materials Science and Engineering: A*. 2005; 405: 313-320.
- [31] Viazzi C, Bonino JP, Ansart F. Synthesis by sol-gel route and characterization of yttria stabilized zirconia coatings for thermal barrier applications. *Surface & Coatings Technology*. 2006; 201: 3889-3893.
- [32] Sniezewski J, Le MY, Lours P, Pin L, Minvie BV, Monceau D, Oquab D, Fenech J, Ansart F, Bonino J-P. Sol-gel thermal barrier coatings: Optimization of the manufacturing route and durability under cyclic oxidation. *Surface & Coatings Technology*. 2010; 205:1256-1261.
- [33] Pin L, Ansart F, Bonino J-P, Maoult YL, Vidal V, Lours P. Processing, repairing and cyclic oxidation behaviour of sol-gel thermal barrier coatings. *Surface & Coatings Technology*. 2011; 206:1609-1614.
- [34] Pin L, Ansart F, Bonino J-P, Le Maoult Y, Vidal V, Lours P. Reinforced sol-gel thermal barrier coatings and their cyclic oxidation life. *Journal of the European Ceramic Society*.
- [35] Ren C, He YD, Wang DR. Cyclic oxidation behavior and thermal barrier effect of YSZ-(Al₂O₃/YAG) double-layer TBCs prepared by the composite sol-gel method. *Surface & Coatings Technology*. 2011; 206: 1461-1468.
- [36] Monceau D, Oquab D, Estournès C, Boidot M, Selezneff S, Thebault Y, Cadoret Y. Pt-modified Ni aluminides, MCrAlY-base multilayer coatings and TBC systems fabricated by Spark Plasma Sintering for the protection of Ni-base superalloys. *Surface & Coatings Technology*. 2009; 204: 771-778.
- [37] Boidot M, Selezneff S, Monceau D, Oquab D, Estournès C. Proto-TGO formation in TBC systems fabricated by spark plasma sintering. *Surface & Coatings Technology*. 2010; 205: 1245-1249.
- [38] Selezneff S, Boidot M, Hugot J, Oquab D, Estournès C, Monceau D. Thermal cycling behavior of EBPVD TBC systems deposited on doped Pt-rich γ - γ' bond coatings made by Spark Plasma Sintering (SPS). *Surface & Coatings Technology*. 2011; 206:



- [39] Rousseau F, Fourmond C, Prima F, Serif MHV, Lavigne O, Morvan D, Chereau P. Deposition of thick and 50% porous YpSZ layer by spraying nitrate solution in a low pressure plasma reactor. *Surface & Coatings Technology*. 2011; 206: 1621-1627.
- [40] Ramachandran CS, Balasubramanian V, Ananthapadmanabhan PV. Synthesis, spheroidization and spray deposition of lanthanum zirconate using thermal plasma process. *Surface & Coatings Technology*. 2012 206: 3017-3035.
- [41] Bahadori E, Javadpour S, Shariat MH, Mahzoon Fatemeh. Preparation and properties of ceramic Al₂O₃ coating as TBCs on MCrAlY layer applied on Inconel alloy by cathodic plasma electrolytic deposition. *Surface & Coatings Technology*. 2013; 228: S611-S614.
- [42] Kim JH, Kim MC, Park CG. Evaluation of functionally graded thermal barrier coatings fabricated by detonation gun spray technique. *Surface & Coatings Technology*. 2003; 168: 275-280.
- [43] Chwa SO, Akira O. Microstructures of ZrO₂-8wt.%Y₂O₃ coatings prepared by a plasma laser hybrid spraying technique. *Surface & Coatings Technology*. 2002; 153:304-312.
- [44] Wang W, Li C, Li J, Fan J, Zhou X. Effect of gadolinium doping on phase transformation and microstructure of Gd₂O₃-Y₂O₃-ZrO₂ composite coatings prepared by electrophoretic deposition. *Journal of Rare Earths*. 2013; 31: 289-295.
- [45] Vassen R, Cao X, Tietz F, Basu D, Stöver D. Zirconates as new materials for thermal barrier coatings. *Journal of the American Ceramic Society*. 2000; 83: 2023-2028.
- [46] Moskal G, Swadźba L, Hetmańczyk M, Witala B, Mendala B, Mendala J, Sosnowy P. Characterization of microstructure and thermal properties of Gd₂Zr₂O₇-type thermal barrier coating. *Journal of the European Ceramic Society* 2012; 32: 2025-2034.
- [47] Ma W, Mack D, Malzbender J, Vaßen R, Stöver D. Yb₂O₃ and Gd₂O₃ doped strontium zirconate for thermal barrier coatings. *Journal of the European Ceramic Society*. 2008; 28: 3071-3081.
- [48] Zhao H, Levi CG, Wadley HNG. Vapor deposited samarium zirconate thermal barrier coatings. *Surface & Coatings Technology*. 2009; 203: 3157-3167.
- [49] Vassen R, Cao X, Dietrich M, Stöver D. Improvement of new thermal barrier coating systems using layered or graded structure. In: Singh M, Jessen T (Eds.) *The 25th Annual International Conference on Advanced Ceramics and Composites: An Advanced Ceramics Odyssey*, Cocoa Beach of Florida: American Ceramic Society; 2001p 435.
- [50] Friedrich CJ, Gadow R, Lischka MH. Lanthanum hexaaluminate thermal barrier coatings. In: Singh M, Jessen T (Eds.) *The 25th Annual International Conference on Composites, Advanced Ceramics, Materials, and Structures: B*, Cocoa Beach of Florida: American Ceramic Society; 2001. p 372-375.
- [51] Xie X, Guoa H, Gongga S, Xu H. Lanthanum–titanium–aluminum oxide: A novel thermal barrier coating material for applications at 1300°C. *Journal of the European Ceramic Society*. 2011; 31: 1677-1683.



10.22214/IJRASET



45.98



IMPACT FACTOR:
7.129



IMPACT FACTOR:
7.429



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089  (24*7 Support on Whatsapp)