Available online at www.sciencedirect.com

SciVerse ScienceDirect

Journal of the European Ceramic Society 32 (2012) 3995–4002

www.elsevier.com/locate/jeurceramsoc

Short communication

Multilayer YAG/Re:YAG/YAG laser ceramic prepared by tape casting and vacuum sintering method

Fei Tang [a,b], Yongge Cao [a,c,*], Jiquan Huang [a], Wang Guo [a], Huagang Liu [a], Qiufeng Huang [a], Wenchao Wang [c]

[a] *Key Lab of Optoelectronic Materials Chemistry and Physics, Fujian Institute of Research on the Structure of Matter, Chinese Academy of Sciences, Fuzhou 350002, China*

[b] *Graduate School of the Chinese Academy of Sciences, Beijing 100039, China*

[c] *Department of Physics, Renmin University of China, Beijing 100872, China*

Received 14 May 2012; accepted 27 June 2012
Available online 21 July 2012

Abstract

This paper reports the use of tape casting and vacuum sintering process for the fabrication of optical grade YAG/Re:YAG/YAG (Re = Yb or Nd) composite laser ceramic. The influence of dispersant content on the rheological behavior of the slurry, the microstructure, the optical and laser performances, were studied. The experimental results showed that laser output at 1030 nm was generated for YAG/Yb:YAG/YAG with threshold absorbed pump power of 4.33 W and slope efficiency of about 12% when the transmission of output coupler (T_{oc}) was 2.3%. For YAG/Nd:YAG/YAG ceramic, 1064 nm laser output was obtained, and the slope efficiency increased from 30% to 38% while T_{oc} changed from 2.3% to 10%.
© 2012 Elsevier Ltd. All rights reserved.

Keywords: YAG; Composites; Tape casting; Optical properties

1. Introduction

The fabrication of multilayer composite materials has become an effective route to achieve the combination and optimization of various properties/functions of any individual components.[1,2] The greatest fabrication challenge of this kind material is focused on the integrity of composite structure, as well as the one-step moulding of the composite. For example, for the fabrication of multilayer composite laser ceramics, the chemical compositions of each layer may be different, and therefore each layer has its own optimal sintering temperature; high-density pores may exist at the interface of adjacent layers, which are quite difficult to be eliminated; the difference in refractive indexes of adjacent layers is particularly problematic for laser output. These shortages lead to the difficult fabrication of high quality multilayer composites laser ceramic.

Indeed, the fabrication of laser ceramics, especially multilayer structural composite, is one of the most difficult projects among all ceramic materials. Up to date, a large number of methods, such as spin-assembly,[3,4] tape casting process,[5,6] magnetron sputtering,[7] plasma-spray,[8] hot molding,[9] pressure assisted sintering,[10] laser cladding[11] and electro-deposition[12] have been developed to fabricate composite structures. However, it seems that only tape casting process shows great potential in fabricating multilayer composite laser ceramics. Recently, Ter-Gabrielyan et al. have made significant progress in the fabrication of multilayer composite laser ceramics (Er:YAG) by tape casting assisted hot isostatic press (HIP) sintering.[6] The biggest drawback of their fabrication is the high cost originated from HIP process.

Herein, we report the successful fabrication of three-segment YAG/Re:YAG/YAG (Re = Yb or Nd) composite laser ceramics by the combination of tape casting process and simple vacuum

* Corresponding author at: Key Lab of Optoelectronic Materials Chemistry and Physics, Fujian Institute of Research on the Structure of Matter, Chinese Academy of Sciences, Fuzhou 350002, China. Tel.: +86 591 83721039; fax: +86 591 83713291.

E-mail address: caoyongge@fjirsm.ac.cn (Y.G. Cao).

0955-2219/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jeurceramsoc.2012.06.022

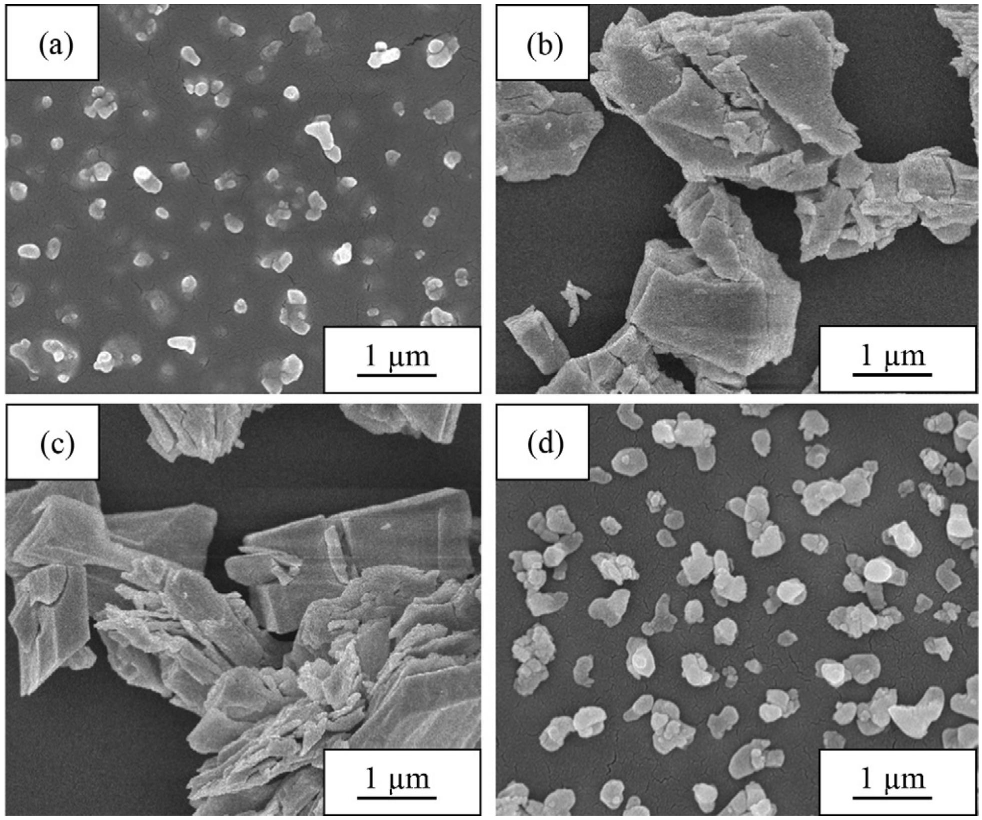

Fig. 1. SEM images of the precursor powders: (a) Al_2O_3, (b) Y_2O_3, (c) Yb_2O_3 and (d) mixed powders after milled.

sintering, without HIP process. Key issues of the fabrication were investigated, microstructure and optical properties of the composite ceramics were studied, and laser performance was further demonstrated.

2. Experiment procedure

2.1. Fabrication of composite ceramics

The starting materials were commercially available powders of high-purity α-Al_2O_3 (99.99%, Sumitomo Chemical Co. Ltd, Japan), Y_2O_3 (99.99%, Alfa Aesar, United States), and Re_2O_3 (99.99%, Alfa Aesar, United States) (Re = Nd or Yb), as shown in Fig. 1(a)–(c). With chemical composition of $(Re_xY_{1-x})_3Al_5O_{12}$ (x = 0.02 for Re = Nd, and x = 0.2 for Re = Yb), these powders were mixed and milled for 24 h in the mixed solvent of 40 wt% ethanol and 60 wt% xylene, and 4 wt% fish oil was used as dispersant to modify rheological behavior of the slurry. The weight ratio of powders to solvent was 13:7. Then, binder and plasticizer were introduced into the obtained slurry for additional milling for 16 h. In this study, 6 wt% polyvinyl butyral was used as binder, while 3 wt% butyl benzyl phthalate and 3 wt% polyalkylene glycol were selected as plasticizers. After the milling process, tape casting process was carried out with gap height of 0.7 mm and casting speed of 1.2 m/min. The thickness of the obtained tapes was 0.12 mm. Eighteen green tapes were stacked, and laminated at 120 °C under 30 MPa for 10 min to obtain the green samples. The containing organics were burned out in oxygen atmosphere at 700 °C for 10 h, and then the samples were sintered at 1720 °C for 20 h under vacuum conditions of 10^{-6} Torr. Followed by polishing process and annealing treatment, Optical-grade ceramic with size of 10 mm × 10 mm × 2.1 mm was achieved.

2.2. Properties characterization

The rheological behavior of the slurries was monitored by the viscometer (BROOKFIELD DV-II+). The microstructure of surface and cross section for the obtained ceramics were characterized by means of scanning electron microscopy (JSM-6700F, JEOL). The optical transmittance was measured by UV/Vis/NIR spectrophotometer (Lambda-900, PerkinElmer). The fluorescence spectra, as well as decay curves, were recorded using a spectrophotometer (Edinburgh, FLS920) by taking a microsecond flash lamp (Edinburgh, μF900) as the exciting source. The signals were detected with an NIR PMT (Hamamatsu, R5509).

2.3. Laser experiment

The laser cavity was an end-pumped plano–plano resonator with total cavity length of 35–40 mm, as shown in Fig. 2. Fiber-coupled 808 nm and 940 nm diode-lasers with core diameter of 400 μm were used as the pump sources with C.W. laser operation. Two convex lenses were used to focus the pump beam into the ceramic specimen and to produce the pump light footprint of about 300 μm. The total cavity was mainly composed

Download English Version:

https://daneshyari.com/en/article/1474552

Download Persian Version:

https://daneshyari.com/article/1474552

Daneshyari.com