Rare-earth Information Center

Insight

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Volume 12 | September 1, 1999 | No. 9

Low-temperature Sintering of AlN

VLSI chips must be mounted on substrates which, among other things, remove heat from the chip. The substrate requirements include high thermal conductivity, a low dielectric constant and thermal expansion which closely matches Si. Aluminum nitride (AlN) is a promising material, but the ability to form a dense sintered ceramic is required. Sintering of pure AlN requires temperatures above 1750°C. Since oxygen is easily dissolved in AlN and degrades the thermal conductivity, high temperatures can degrade the material. Studies using YF_3 as a sintering aid have produced good results, but required several days of annealing. Y. Liu et al. {*J. Mater. Sci. Lett.*, **18**, 703-4 (1999)} produced relatively high thermal conductivity material in 6 h at 1650°C in flowing N_2 gas by using an binary mixture of YF_3-CaF_2. The binary addition resulted in liquid formation at lower temperatures. The YF_3 reacted with the AlN and surface O to form $Y_4Al_2O_9$. Interestingly, the CaF_2 appears to have volatilized during the annealing, and no Ca compounds were found in the material.

Fluorescence Temperature Sensing at Cryogenic Temperatures

Suppose you were asked to measure the surface temperature of the ball bearing or turbopump axis in a liquid propulsion rocket engine. Keeping in mind that the thing is rotating at a reasonable rate and the liquids in question are hydrogen and oxygen, it is clear that you have a bit of a problem. Putting a thermocouple or platinum resistance thermometer on the rotating part is clearly out of the question. IR thermometry does not function very well at cryogenic temperatures. Fluorescence thermometry has been used effectively from 200 to 800 K using Cr^{3+}, and at high temperatures using Nd. F. Bresson and R. Devillers {*Rev. of Sci. Instrum.*, **70**, [7], 3046-51 (1999)} have now demonstrated that Yb^{2+} ions can be used in the 20-120 K region. Since the target environment is less than ideal, they used the thermal decay time dependence on temperature rather than the thermal efficiency in order to be independent of intensity fluctuations. Measuring the decay time on a rotating axis would seem to be a bit tricky, but they have a clever solution. A set of fiber optics carries the excitation light, and detects the fluorescence signal at a number of positions around the shaft. Thus, a spot of dye is excited when it passes the excitation fiber, and its fluorescence is measured as it passes each sensing fiber. As the rotation speed is known, a number of data points at fixed time intervals are collected, and the decay constant can be determined.

SnO_2-Y_2O_3 NO_x Sensors

Nitrogen oxides, NO_x, are common air pollutants generated from both cars and combustion facilities. There is considerable unmet demand for a small, cheap NO_x sensor that can be used in feedback control systems. Considering that high sensitivity is required between 0 and 5 PPM, this is a rather stringent set of requirements. SnO_2 thin films, prepared by a variety of methods, have been shown to be effective in detecting low levels of NO_x, but may require elevated temperature operation. One way of increasing sensitivity is to increase the surface area by making a porous film. Such films can be made by spin coating with sol-gels. G. Fang et al. {*J. Mater. Sci. Lett.*, **18**, 639-41 (1999)} have demonstrated such thin film sensors. Pure SnO_2 was found to be relatively insensitive, but the addition of small amounts of Y_2O_3 resulted in very good sensitivity peaking at 330 K. As is frequently the case with rare earth oxide additions, the Y_2O_3 serves as a grain refiner, resulting in a fine uniform microstructure with fine pores, which enhance not only the sensitivity but also the response time.

$YMnO_3$ Ferroelectric Thin Films

Ferroelectrics exhibit a unique ability to retain an electric polarization in the absence of an applied electric field. This stable polarization results from the alignment of internal dipoles within the ferroelectric material. Application of an electric field controls this alignment, allowing storage of digital information in the material. Since the polarization is retained after the polarizing field is removed, nonvolatile memory devices may be constructed using ferroelectric films. $YMnO_3$ has been proposed for use in a metal-ferroelectric-insulator-semiconductor field effect transistor (MFIS-FET). Films of this material have been prepared by rf magnetron sputtering and pulsed laser deposition, but a preferred method would be a solution technique, which allows control of chemical composition, low process temperature and relatively low costs. Unfortunately, these films have been plagued by high leakage currents. Ferroelectrics are, by necessity, insulators, since conduction electrons or holes would simply move to cancel out any polarization. If a thin insulating film has defects, such as porosity, microscopic shorting paths can form so that the currents flowing along these paths prevent a sufficiently large electric field from being applied across the sample to polarize the material. H. Kitahata et al. {*Appl. Phys. Lett.*, **75**, [5], 719-21 (1999)} have recently shown that the key to making good $YMnO_3$ thin films using the solution route lies in vacuum annealing of the films.

Mt. Weld Feasibility Study

A high grade deposit of rare earth ores, which preliminary estimates indicate could supply 10 percent of the world demand in 2010 and last at least thirty years, is located at Mt. Weld near Laverton in Western Australia. Ashton Mining Limited currently is the sole owner of Mt. Weld. Ashton has recently signed an agreement with Lynas Gold NL to complete a feasibility study to confirm the economics of developing the deposit. The study will include pilot plant production of rare earth products. In return for financing the study, Lynas Gold has the right to earn a 35% interest in the project. This interest has the potential to reach 60% should the project be developed. Contact Mr. Glenister Lamont, General Manager – Corporate, Ashton Mining Limited, Telephone: 61 3 9832 9225, Fax: 61 3 9832 9211, Email: investor@ashton.net.au or Les Emery, Managing Director, Lynas Gold NL, 50 Colin Street, West Perth WA 6005, Telephone: 61 8 9481 3400, Fax: 61 8 9481 3455, Email: lynas@lynasgold.com.au.

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