Thin Films
Room 329- - Session TF1-WeA
Thin Film - Based Combinatorial Methods

Moderator: J. Kidder, Vermont Technical College

3:40pm **TF1-WeA6 Combinatorial Approach to Functional Thin Film Materials*, I. Takeuchi,*** University of Maryland **INVITED**

In this talk, I will describe the combinatorial materials research methodology we have developed using thin film techniques targeting a variety of functional materials. The basic idea of combinatorial thin film deposition systems is to create controlled compositional variation across given chips. Versatile compact combinatorial pulsed laser deposition systems are used for pursuing metal oxide systems. For studying metallic alloys, an UHV co-sputtering system is used to fabricate natural composition spreads. In this system, three magnetron guns are placed in a parallel geometry in order to maximize the coverage of ternary compositional phase space on three inch wafers. The spreads are primarily used for rapidly exploring novel phase space of magnetic materials. Various high-throughput characterization tools are used for rapid characterization of thin film combinatorial libraries and composition spreads. They include quantitative scanning microwave microscopes for studying dielectric/ferroelectric and resistive materials, scanning SQUID microscopes for mapping of magnetic properties and a scanning X-ray diffractometer for structural characterization. We also implement micromachined device libraries such as arrays of cantilevers for investigation of smart materials. Our studies have led to identification of novel compositional regions of ferromagnetic shape memory alloys.

4:20pm **TF1-WeA8 Preparation of Ternary Alloy Libraries for High-throughput Screening of Material Properties by Means of Thick Film Deposition and Interdiffusion: Benefits and Limitations*, A. Rar,*** Oak Ridge National Laboratory and The University of Tennessee*; E.D. Specht,* Oak Ridge National Laboratory*; E.P. George, G.M. Pharr,* Oak Ridge National Laboratory and The University of Tennessee

Numerous techniques have been developed for making ternary alloy libraries for combinatorial materials development. Two popular approaches for synthesizing films are: (i) co-deposition from 3 different pure element sources and (ii) preparation of multilayer thin films with thickness gradients in different directions for each component, followed by annealing of the films to achieve local alloying. However, both methods have limitations. In the first, the elemental distribution is non-linear, the film thickness is not constant, and regions with low concentrations of one or more elements are difficult to achieve. In the second approach, synthesis of thick films may be a problem because of the large numbers of layers required. One possible solution is to deposit a single relatively thick layer for each element, followed by annealing to achieve alloying. This approach was examined for the Ni-Fe-Cr ternary system. Spatially resolved alloy properties were compared with well known structural properties by means of rapid XRD mapping with synchrotron radiation. Specimens were prepared by depositing films onto sapphire substrates with an e-beam evaporation system. After deposition, the layers were interdiffused by annealing in different environments. The quality of the resulting specimens was examined using cross sectional SEM, electron microprobe analysis, angular resolved x-ray fluorescence, and XRD. The main problems were encountered during annealing. Selection of annealing temperatures and times that could be used to produce good interlayer diffusion without Cr evaporation or Kirkendall voiding proved difficult. In addition, there was a tendency to form chromium oxide at the surface. Despite these problems, an isothermal section of the ternary phase diagram was reasonably well reproduced.

4:40pm **TF1-WeA9 Combinatorial Pulsed Laser Deposition for Investigation of Metal Oxide Systems*, K.S. Chang,*** University of Maryland, College Park

Pulsed laser deposition (PLD) is an efficient technique for fabrication of a variety of thin film materials especially metal oxides. We have developed a compact combinatorial PLD system. The heart of the system is contained in a portable combinatorial thin film deposition flange which can be fitted into any physical vapor deposition system. The eight-inch flange features an automated two-dimensional shutter/mask system and a rotatable substrate heater which can go up to 800 ÂºC. Spatially selective shadow depositions are carried out by controlling the motion of the shutter/masks which glide over a mounted substrate during and in between depositions. Different designs of discrete combinatorial libraries and continuous composition spreads can be achieved by cutting different apertures on the replaceable masks made of stainless steel sheets. SnO2 based semiconductor gas sensor libraries consisting of 16 discrete compositions have been fabricated, and their operation as electronic noses were successfully tested. By monitoring the number of laser pulses, one can control the deposition of materials at atomic layer level. This layer-by-layer technique can be used for epitaxial growth of continuous composition spreads with controlled compositional variation across chips. Some of the materials we have looked at include ferroelectric BaTiO3-SrTiO3 composition spreads where continuous change in microwave properties were studied and MgO-ZnO composition spreads which can be used for construction of solar blind multi-channel UV detector arrays.

5:00pm **TF1-WeA10 Gadolinium-doped Yttrium Aluminum Garnet Ultraviolet Emitting Materials Deposited by rf Reactive Magnetron Sputtering*, Y. Deng,*** *J.D. Fowlkes,* University of Tennessee*; J.M. Fitz-Gerald,* The University of Virginia*; P.D. Rack,* University of Tennessee

Gadolinium is known to radiate in the ultra-violet region at ~ 312nm and 275nm due to intra-band 4f transitions when suitably doped in oxide host materials. To investigate the ultraviolet Gd emission, thin films of gadolinium-doped with yttrium aluminum garnet (YAG:Gd) have been deposited by rf reactive magnetron sputtering. The parameters in this work include RF power, substrate temperature, O2 partial pressure ratio and annealing temperature. An optimized combinatorial process has been obtained by statistical analysis on a factorial design of experiment. The structure and composition of the films have been characterized by scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS). The crystallinity of the films has been investigated by X-ray diffraction (XRD). The effect of Gd doping level on the cathodoluminescent (CL) properties of the films has also been studied and has been correlated to the chemical and microstructural properties of the films.

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