TUESDAY AFTERNOON, June 21

This paper will concentrate on the later strand and will review past and current developments and offer insights to as yet unforeseen possibilities.

13:30 p.m. - 15:30 p.m. Room A
SMS-I: SMART MATERIALS AND STRUCTURES, NDE

SMS-01: Using Photon for Non-destructive Testing of Thick Materials
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We present a non-destructive testing method for thick materials using positrons produced through gamma-conversion. Positron annihilation spectroscopy using positron annihilation lifetimes has been successfully studied for non-destructive material testing. A positron, which is inspection probe, is annihilated with an electron at the front of the material. The application of the positron lifetime method is restricted to thin materials. A photon with energy exceeding 1.02MeV reaches the materials' depth and can produce a positron through gamma-conversion. Such a photon-produced positron is a probe for thick materials. The probability of gamma-conversion, however, is low. The method of photon-produced positron annihilation lifetimes is restricted by statistics. We estimated the background contributions and the statistical uncertainties for the positron lifetime measurements using an example of monitoring SUS316 stainless steel fatigue. Assuming the detection efficiencies of photons at each photon-counting device to be 50%, it takes approximately 40 minutes to measure the lifetimes within 10% statistical uncertainty, which is sufficient time for long term fatigue monitoring.

SMS-02: Measurement of Thin Film Elasticity Using Nanoscopic Contact Resonance of a Flat Tip in Sensitivity-Enhanced Atomic Force Acoustic Microscopy
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Atomic force acoustic microscopy (AFAM) is a possible technique of measuring elastic modulus of very thin films with a thickness of 10 nm or less. In AFAM, the resonant frequency of a micro-cantilever equipped with a tip measures the contact stiffness between a sample and a tip. Our previous works have introduced a concentrated-mass cantilever and a flat tip for enhancing the sensitivity in the detection of contact stiffness, improving reproducibility of measurements, and simplifying evaluation of elasticity. This study demonstrates characterization of 10-nm-thick diamond-like carbon (DLC) film on a hard disk. The contact area and the elastic modulus of a tip were preliminarily determined by use of well-defined samples such as silicon wafers. The resonant frequency observed for the DLC film under the contact radius of about 1.7 nm was not influenced by the substrate. This successfully led to determining the effective Young's modulus of 869 ± 50 GPa.

SMS-03: Detection of Inclusion in Steel Sheet with Leaky Surface Acoustic Wave
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This paper developed a method for detection of inclusion in thin steel sheet, using Leaky Surface Acoustic wave (LSAW). A special lens, which has a hollow in its center and is called as DH lens, was developed for improving the conventional LSAW detection. Experiments show that the improved LSAW method with DH lens is effective in detection of the non-metallic inclusions in steel sheet. Comparison is also carried out between the Longitude Wave (LW) detecting method and the improved LSAW method, the result shows LSAW method can detect the inclusion in 20MHz, while the LW method have to use 100MHz for same detec-
The influence of the ultrasonic frequency on LSAW method is also investigated. And the detected results were verified in SEM (Scanning Electron Microscope) detection.

**SMS-04: Research and Development of Multi-Ferroic Materials and Devices for Smart Systems**

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As research of the composite Multi-Ferroic materials and devices of solid transformation type material, the actuator/sensor material using a magnetic property and the superelastic characteristic were studied. A composite actuator material by combining a shape memory alloy and a ferromagnetic material was designed and fabricated because it can be driven with high speed as well as considerably large deflection by a wireless magnetic field. As for the elemental material, a shape memory alloy CuAlMn and a ferromagnetic material Fe were selected and laminated. The following characteristic evaluations were performed. 1) Difference of the material properties and actuator performance between sandwiches structure (SS) and bimorph structure (BS). 2) Strength of the composite material when changing the thickness and elemental ratio of the structured material. 3) Response speed in the alternative magnetic field. Consequently, these results can show the possibility of a new type of composite actuator.

**SMS-05: Development of High Performance CFRP/Metal Active Laminates**

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This paper describes development of high performance CFRP/metal active laminates mainly by investigating the kind and thickness of the metal. Various types of the laminates were made by hot-pressing of an aluminum, aluminum alloys, a stainless steel and a titanium for the metal layer as a high CTE material, a unidirectional CFRP prepreg as a low CTE/elecetric resistance heating material, a unidirectional KFRP prepreg as a low CTE/insulating material. The aluminum and its alloy type laminates have almost the same and the highest room temperature curvatures and they linearly change with increasing temperature up to their fabrication temperature. The curvature of the stainless steel type jumps from one to another around its fabrication temperature, whereas the titanium type causes a double curvature and its change becomes complicated. The output force of the stainless steel type attains the highest of the three under the same thickness. The aluminum type successfully increased its output force by increasing its thickness and using its alloys. The electrical resistance of the CFRP layer can be used to monitor the curvature to control it.

**SMS-06: Piezoelectric Properties of Sr2xCayNaNb2O15 (SCNN) Ceramics (0.05<x<0.35) for a Smart Patch**

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The study investigating the electrical properties of dense lead-free piezoelectric ceramics in the (1-x)Sr2/3NaNb2O6-x, (1-x)Ca2/3NaNb2O6 (SCNN) system with x ranging from 0.05 to 0.35 is reported here. Materials were produced with Spark Plasma Sintering (SPS) method. Ferroelectric and piezoelectric properties of SCNN greatly depended on the Ca content. The composition with x = 0.15 exhibited the greatest polarization with Pr = 3.0 μC/cm² and piezoelectric constant of d33 = 96 PC/N, whereas the compositions with x = 0.30 and 0.35 almost lost their ferroelectricity and piezoelectricity. Not only investigation of materials properties but also application possibility as a sensor is surveyed. The ultrasonic waves generated by SCNN material as a sensor are much clearer that that by commercially available PZT materials. This study apparently indicates that lead-free SCNN piezoelectric ceramics have potential for electromagnetic application.

**SMS-07: Processing and Characterization of Thin Film Shape Memory Alloys**

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Thin film shape memory alloys (SMA) has been developed with less than 2 μm thickness for MEMS micro-actuator applications. In this study, thin film TiPdNi SMA was processed using Ion Beam Assisted Deposition (IBAD) with and without in situ heat treatment. Films deposited on unheated substrates were found to be amorphous, and subsequently annealed to induce crystallization. Deposition using the IBAD technique with in-situ heat treatment was successful in producing fully martensitic films with 1.5 μm thickness and reduced grain size and film defects. On the other hand, post-deposition annealing lead to bulk diffusion of palladium to the substrate interface and silicon into the bulk film, creating a porous cross section. Deposition using the IBAD technique with in-situ heat treatment did not cause major diffusion of alloying elements from the film into the substrate. Various forms of tensile failures were observed including decohesion and delamination as a result of post deposition annealing. The effects of various processing parameters, and heat treatment conditions, on films microstructure and residual stresses as well as the interfacial properties have been studied.

**AWB-01: Effect of Fillet Geometry to Joint Strength of Four-Pipe-Brazed Specimen for Rocket Nozzle Skirt**

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The strength of the brazed joint of the four-pipe-brazed specimen (4PB), which imitates the rocket nozzle skirt’s wall, is analyzed numerically. The 4PB specimen comprises four pipes brazed side by side with JIS BP4-6 palladium brazing filler metal. The effect of the fillet geometry to the joint strength of the 4PB specimen is investigated. The numerical analysis is conducted for the 4PB of 10 mm diameter with various root gaps from 0.05 to 3.0 mm and various apparent fillet widths from 1.0 to 4.0 mm. The nominal rupture strain is obtained by the comparison of von Mises’ equivalent stress of the fillet and the pipes with their maximum tensile stress. The results show the fracture of the 4PD specimens always occurs at the fillet. The nominal rupture strain tends to have weak correlation with the root gap, but in positive proportion to the apparent fillet width.

**AWB-02: Laser Welding of Dissimilar Metals between AZ31B and A5052-O**

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In case of a combination of dissimilar metals like steel to aluminum alloy, formation of intermetallic layer at the interface can be controlled by