RD-001

Generation of Wedge Waves by Means of Evanescent Light

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A new method for generating ultrasonic waves utilizing evanescent light during the total internal reflection at the surface of a half ball lens is presented. A waveguide with a sharp wedge is employed as a specimen to launch a wedge wave and the edge tip of the waveguide ridge is attached to the lens to create a contact point between them. A low-power pulsed Nd:YAG laser is irradiated into the lens to form the evanescent light. The effect of water confinement in a point-contact configuration is investigated for the ability of generating wedge waves by comparing in an open system. The amplitude of the first mode 1 wedge wave produced by the evanescent light is enhanced more than eight times due to the water confinement. The similar relationship between the direct ablation and the confined ablation for the direct laser irradiation is demonstrated. Although the contact point configuration with the wedge was examined to produce wedge waves in this work, it is also possible for the evanescent light to provide an ultrasonic wave or a shock wave for other applications, such as an extremely small material in a liquid medium.

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RD-002

Development of Precision Measuring Robot of Crawler Type and Feasibility Study of Measuring Unit for Improvement of Measurement Accuracy

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Precision geometrical quantity measurements in electric power stations are absolutely necessary for environmental loading reduction and quality assurance and safety. These precision measurements are difficult manual operations. Specifically, these measurements are done at high places, narrow places, uncomfortable environments, and so on. Therefore, workers in power stations are demanded stressful operations and painful postures among other things. Hence, we study and develop a precision geometrical measuring robot to relieve stress and to improve working environment.

Example of precision geometric quantity measurements in electric power stations include length measurement, form measurement, geometrical tolerance measurement, surface roughness measurement, surface texture measurement, wear measurement, and so on. In this research, we propose and develop the precision geometrical measuring robot of crawler type enabled in surface roughness measurement because surface texture influences environmental loading and lifetime of power station. To the best knowledge of authors, this research is the first that introduces travelable precision geometrical measuring robot for surface roughness measurement. The handling robots that supply workpieces to surface roughness instruments have been developed [1], however, we do not know the research of robotization and self-propulsion for roughness measurement instruments. In addition, in this research, we develop a measuring unit to improve the accuracy of roughness measurement. Weight reduction of the robot is essential to enable self-propulsion and smooth motion, however, the measurement accuracy of the measuring robot decreases due to stiffness and stability reduction by light-weighted structure. Therefore, we propose a measuring unit using electromagnets. This research designs and develops mechanism and structure of measuring unit. The effectiveness and capability of developed measuring unit was examined through experiments. From results of measuring experiments, standard deviations of roughness parameter value Ra were improved from one third to half by using the measuring unit with electromagnets.

Keyword: precision measuring robot, robotized precision measurement instrument, surface roughness measurement, surface texture, crawler robot

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RD-003

Development of Finite Element Analysis Model of Stress Concentration on Tool Corner for a Tandem Process of Deep Drawing

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Deep drawing [1] is a compression metal forming process in which a sheet metal blank is radially drawn into a forming die by the mechanical action of a punch. Deep drawing process is widely used in various industries due to its versatility, good strength and light weight design. In addition, a tandem multiple stage production system of deep drawing has an advanced performance to reduce several cost problems because of reducing material waste under non-lubricant condition and unmanned continuous converting. However, if any unbalanced mass flow balance occurs at a local zone such as a stepped shape due to several variation of inputted working material, its misalignment of inputted material affects the post stages of tandem processing. Hence, the critical strength of dies and/or the life time of rod tool become severe, although the design details of tandem die tools are quite conservative due to the complicated mutual interference from the upper stream up to the lower stream. Since any unbalanced problem is not settled down in the single isolated stage generally, all the stages of die/punch working flow must be investigated synthetically for adjusting the continuous deep drawing process. Therefore, appropriate simulation system of multiple stage deep drawing process is required for estimating a flow resistance of work material and an overloading state of the die surface and/or the punch rod. According to the previous project research of cold deep process by Hanh et al. [2], a ceramics-based die holder strength was numerically analyzed during the full stroke motion and an optimal profile of die holder was designed and proposed through the proposed FEM model based breaking estimation of die holder. In the middle stages of this tandem process, there are other problems in the punch rod parts as well as that of die holder. We need to reveal the fracture reason of specific portion of chosen punch rod, for examples. As the external conditions for this deep drawing process, the virtual-slight variation of inputted volume size of work material, the variation of temperature of the work material must be discussed using an FEM simulation model. At the same time, to detect the severe position of failure strength is necessary for inspecting or diagnosing the critical loading condition during the full stroke.

In this work, firstly, a detection problem of severe stress condition in a full stroke motion for the specified middle stage deep drawing problem was investigated by developing an FEM elasto-plastic model composed of three parts: die holder, work material, and the punch rod. Seeing the full stroke motion, the rod end reaction force was reviewed to detect the severe timing, while the severe pushed portion on the punch rod was retrieved to measure the stress distribution on any broken-expected portion. Through this simulation and detecting the stress state of broken-expected portion, the authors developed a fundamental analysis model against the specified inputted work material. Furthermore, by varying the inputted size of work material and so on, the sensitivity (stress variation) of focused parts of punch rod was reviewed.

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RD-004

Effects of Cutting Parameters on Cutting Characteristics of Nylon Film Subjected to Wedge Indentation

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Abstract

In this research work, we aim to investigate the cutting characteristics of a nylon film in the wedge indentation process. This method process is well known and widly used for cutting sheet materials in the packaging industrial, for example resin sheets, paperboards, protective film, etc. However, quality of sheared profile and stable cutting depth along the long blade are the main problems in this kind of cutting. These problems are caused by many mechanical conditions for making the cutting process such as tip thickness, surface roughness of the blade or the effect of the counter plate. Nagasawa et al. [1],[2] investigated both experimentally and nummerically the effect of crushed tip to the cutting characteristic of white-coated paperboard. Seksan et al. [3] also reported on the effect of tip profile on cutting processability on aluminum sheet. Nevertheless, these investigations were not expanded to other resin sheets. Recently, although nylon film is widely used for food packaging due to its unique properties such as low cost, high stiffness, high transparency, thermoformability, etc., there are not almost any academic reports of cutting deformation of this kind of material.

In order to reveal the effect of cutting parameters on the cutting features, the indentation experiment of 0.16 mm thickness of nylon film was conducted; the cutting line force was gotten using recording unit; bent-up angle and shear profile were observed using a high-speed camera. From the experiment results, it is found that tip thickness is an important factor affected to the bent-up angle and quality of sheared profile of the nylon film. Also, a two-dimensional finite element method analysis using MSC. Marc 2015 programe was carried out by varying the tip thickness of blade tip, friction coefficient to compare with the experiment.

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RD-005

Displacement Measurement Based on Direct Phase Determination for Laser Heterodyne Interferometry

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In recent years, metrology systems based on heterodyne interferometry have widely utilized in high-precision displacement measurement applications because they have the advantages of high resolution and speed, high noise-immunity and, traceability to the meter definition. High-performance industrial machines, for example as lithographic tools which is used to fabricate semiconductor products, usually adopt heterodyne interferometers to measure the motion of machine axes [1]. The need for a high displacement measurement velocity of the heterodyne interferometers is one of increasing throughput requirements of these tools.

In this paper we, therefore, propose a direct phase determination using simple phase lock loop technique and null method for high-speed displacement measurements in optical heterodyne interferometers. Two heterodyne signals consisting of the reference and the measurement are applied to the proposed method. The measurement signal multiples with the reference signal which will be phase-shifted by a digital phase shifter. The product is low-pass filtered in order to eliminate beat-frequency components and retain a DC component. The DC component as error output signal should be zero by using phase lock loop and null method so that the shifted-phase of the reference becomes the changed-phase of the measurement, which generated by the displacement in the interferometer. Finally, the phase shift between the two signals is accumulatively found by an integrator. In the experiment, the phase measurement performance is implemented to simulate two 2.7MHz-pure sinusoids from a precise function generator. The initial results show that the method may provide measurable phase changes of 360degree (±360degree) in the phase-modulated heterodyne signal (measurement signal) with a modulated frequency up to 20kHz, corresponding to a target-displacement velocity of ~13mm/s in a single path heterodyne interferometer. The principle of the proposed method, experiments, and results are discussed in the paper.

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RD-006

Frequency Stabilized Laser near 531nm Region

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Nanotechnology and precision manufacturing need precise displacement methods. The optical interferometers are most suitable candidates for it, because the interferometers can be traceable to the meter definition. From the meter definition, frequency-stabilized light sources are required for the interferometers. The length of measured by optical interferometer is represented by optical path length, which is product of air refractive index and geometric length. From the relationship, the optical interferometers are easily affected by fluctuations of air refractive index. The multi-color method is effective to correct the fluctuations of air refractive index. In order to perform the correction using the multi-color method, multi-color frequency stabilized light sources, for example 780nm, 633nm and 531nm, are required. In the paper, we discuss a frequency stabilized laser near 531nm region using the iodine saturated absorption.

RD-007

Frequency Stabilization of 633 nm DBR Laser Diode

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An optical interferometer can be cited as a precise length measuring sensor having resolution of subnanometer. The optical interferometer can measure the displacement of a measured object with reference to the wavelength of the laser light source. Therefore, in displacement measurement using an optical interferometer, the measurement uncertainty depends on the wavelength or frequency of the laser light source.

In this research, frequency stabilization is performed by using absorption line of iodine molecule, and distributed Bragg reflection type laser diode is used for light source. This laser diode has high output, stable, wide tuning range, narrow line width, and is suitable for interferometer. Utilizing the characteristics of the distributed Bragg reflection laser diode, we stabilize the frequency by locking the frequency to the absorption line of iodine, and aim for realization of a displacement measuring interferometer. As a preliminary experiment of DBR-LD frequency stabilization, by confirming the iodine absorption line by directly modulating the injection current of the laser diode by linear absorption spectroscopy, linear absorption of iodine could be confirmed. Currently, we are checking the saturated absorption line. To lock the frequency to the absorption line of iodine.

RD-008

High-Temperature Oxidation of Ni/Al_2O_3 Composites with Different Ni Content

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Alumina (Al_2O_3) has been widely used in industry such as cutting tool and refractory because of excellent properties as high-temperature resistance, high hardness and high chemical stability. On the other hand, alumina is easy to be broken due to its brittleness. This weakness of alumina has been restricted their application. To overcome this weakness, dispersion of non-oxide phase such as nickel (Ni) to alumina matrix can increase their toughness and give self-healing function at high temperatures in air. Maruoka and Nanko reported self-healing of Ni/ Al_2O_3 nanocomposites. Ni dispersoid in the matrix were oxidized at high temperatures in air. $NiAl_2O_4$ as the oxidation product was filled up the surface crack and recovered the mechanical strength of the composite [1]. High-temperature oxidation behavior of Ni dispersed in alumina matrix composite has been reported by Nanko and his co-workers [2]. In high-temperature oxidation of Ni/Al_2O_3 composites, inward diffusion of oxygen promoted mainly growth of the oxidized zone. The growth rate of the oxidized zone followed the parabolic law. In this study, influences of nickel content on their high-temperature oxidation resistance were discussed.

Ni/Al_2O_3 composite powders with different Ni contents (1, 5, 10 and 15 vol%Ni) were prepared from a commercial Al_2O_3 powder and $Ni(NO_3)_2 \cdot 6H_2O$. Bulk Ni/Al_2O_3 composites were prepared by pulsed electric current sintering. All samples were consolidated at 1250°C under 50 MPa uniaxial pressure for 5 min holding time in the vacuum and were attained 99% of the theoretical density. High-temperature oxidation experiments were conducted at temperatures ranging from 1200 to 1300°C for 6-24 h in air with heating rate 400°C/h. Phase identification of samples were conducted with X-ray diffraction (XRD). The thickness of oxidized zone was obtained by using the scanning electron microscope (SEM).

High-temperature oxidation behavior of 1, 5, 10 and 15 vol% Ni/Al_2O_3 composites obeyed the parabolic law. $NiAl_2O_4$ as the oxidation product was observed on the surface of samples. Growth rate of the oxidized zone were decreased with increasing Ni content.

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RD-009

Straitness Measurement Using Two-Color Lasers as References

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In recent years, from the advance of large-sized structures and the like, there is a demand for linearly arranging objects and noncontact and precise linear measurement for examining flatness.

For this purpose, it is effective to use a laser. However, when configuring a linear meter by using a laser in the atmosphere, a change in direction of the laser due to atmospheric fluctuation becomes a big problem.

One way to solve this problem was to use a laser with two wavelengths as a light source by utilizing the principle that laser fluctuation has wavelength characteristics.

Movement of the laser wavefront of two wavelengths is shot with a moving picture using the camera to which the CMOS sensor is attached.

The position of the center of gravity of the laser wavefront is measured from the luminance of the photographed laser wavefront.

Then, correction is made to reduce the influence of air fluctuation using the measured data of the barycentric position of the laser wavefront of the two wavelengths.

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RD-010

Preparation of High Purity Magnesium Sheet by Vacuum Distillation, Extrusion and Rolling

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Recently, demand of magnesium is increased because magnesium is lightweight and recyclability. It needs the recycling process with less contamination of impurities because corrosion resistance of magnesium is decreased by contamination of impurities. Vacuum distillation method utilizing difference in vapor pressure between each element is one of effective method for solving that problem. Magnesium has anisotropy of tensile properties because the crystal structure of magnesium is hexagonal close packed structure. It made the sheet by extrusion and rolling, after vacuum distillation. The improvement of the mechanical properties can be expected by conditions such as the extrusion ratio and the rolling ratio.

In this study, it examined the preparation of high purity magnesium sheet from AM60 magnesium alloy by vacuum distillation, extrusion and rolling. AM60B magnesium alloy (Mg-6.0%Al-0.29%Mn) of 300gf was inserted into the crucible, evacuated to 1Pa or less with an oil-sealed rotary pump, then held at material temperature of 600°C, and recovery temperature of 380°C for 8h. After the vacuum distillation, three magnesium condensates of φ45mm×20mm into a sheet have width of 30 mm by extrusion processing. Extrusion conditions were extrusion temperature 375°C, extrusion ram speed 2mm/s, extrusion ratio 7, 9, 11, 13, and 18. The obtained extruded material was cut to a length of 70mm and rolled in the direction of 90 ° in the extrusion direction. The rolling conditions were rolling temperature of 375°C, roll speed of 10mm/min, rolling reduction of 10%/pass, and a target thickness of 2mm.

As a result, magnesium sheet of a purity of 99.99% or more and width 70mm was prepared by vacuum distillation, extrusion and rolling. The hardness of rolled specimen is larger than those of extruded specimen. The ultimate tensile strength of the 90 degrees direction is greater than those the 0 degrees direction. When the final working ratio is the same, the property of the specimen is about same. When making the sheet by changing the working ratio, the rolling after the extrusion is effective.

RD-011

Study on Influencing Factors on Fatigue Strength Characteristic of Flake Graphite Cast Iron

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Flake graphite cast iron has been widely applied to structural members of automobiles engine because it is possible to produce large component with complicated shape by low cost. It has been reported that the cooling rate varies in locally depending on shape and thickness of the casting member [1]. Therefore, shape, size and distribution of graphite, moreover microstructure of the matrix changes and affects the mechanical properties. In this study, fatigue strength tests were carried out in flake graphite cast irons produced by applying different cooling rate to investigate influencing factors on the fatigue strength characteristics. In the casting process of the materials tested, cooling rate was adjusted to obtain different matrix after graphite flake was formed. According to result of evaluation for the maximum size of graphite with extreme value statics, sizes of graphite were the similar, however, hardness values of the matrixes were different in two different flake graphite cast irons produced in the present study. It was confirmed that materials produced had the same graphite size but had different matrix. Results of fatigue strength test for the two cast irons showed that the fatigue strengths for two cast irons tested were the similar. Fatigue crack initiation and propagation behavior was observed by replication technique during fatigue test. Fatigue crack was initiated from graphite flake at the early stage of the total fatigue life. Moreover, the fatigue life was well estimated based on fracture mechanics by using the maximum size of graphite flake estimated and threshold stress intensity factor value. Therefore, .it is concluded that effect of matrix is not significant but size and distribution of graphite flake is dominant on fatigue strength characteristic of flake graphite cast iron.

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RD-012

Instabilities of Hydrogen-Methane-Oxygen-Nitrogen Premixed Flames on a Flat Burner

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Abstract

Environmental issues, such as global warming and air pollution, are serious problems in the world. These problems are mainly caused by emissions of carbon dioxide and nitrogen oxide from combustion. To reduce emissions of carbon dioxide and nitrogen oxide, hydrogen lean premixed flames are focused. However, hydrogen premixed flames are invisible and have high burning velocity. Addition of methane to hydrogen is effective to make visible flames. Addition of inert gases is also effective to suppress high burning velocity of hydrogen premixed flames. Moreover, hydrogen lean premixed flames tend to form cellular flame fronts owing to intrinsic instability. It is necessary to elucidate the instability of hydrogen premixed flames to control lean combustion in practical applications. We conducted the experiments with H_2-O_2-CO_2 premixed flames formerly to evaluate the influence of carbon dioxide on intrinsic instability. In this paper, we focused on nitrogen as an inert gas and performed the experiments with H_2-CH_4-O_2-N_2 lean premixed flames formed on a flat burner. In the experiments, we obtained the behaviors and shapes of premixed flames by direct photography and measurement of light emission intensity. We took the direct photograph using a digital camera to obtain the cell width on the flat burner, and reconstructed the attractor of light emission intensity to obtain the dynamic behavior.

As the results, the equivalence ratio of the lower flammable limit did not change even if the flow rate changed. As the flow rate decreased, the cell width became larger. When the flow rate was large, there were quasi-periodic behaviors in premixed flames; when the flow rate was small, there were not quasi–periodic behaviors. At small flow rate, premixed flames form near the flat burner because the burning velocity under the adiabatic conditions is high in comparison with the flow velocity. Thus, the heat loss increases, and then the thermal-expansion effects become weaker. In addition, the heat loss has a pronounced influence on intrinsic instability at low equivalence ratios. Therefore, premixed flames tend to be unstable when the flow rate is small.

RD-013

Study on Liquid Level Sensing Based on Wedge Waves Propagation

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There has been an increasing interest in wedge waves propagating along the tip of an ideal sharp elastic wedge because these waves are dispersionless, their propagation velocity is lower than the Rayleigh wave velocity and the acoustic energy is concentrated at the tip of the wedge. In this work, three dimensional finite element analysis method (FEM) has been applied to a sharp metal wedge to examine the generation and propagation of wedge waves. The material is aluminum and the wedge angle is thirty-degree. It has been shown in the numerical simulation that the velocities of the wedge waves estimated by the FEM almost agree with the measured values and also shown that The velocity of wedge waves along a wedge immersed in water is over 30% lower than that in the air. Based on the results, two methods for determining liquid level using a long wedge are proposed. The validity of the proposed methods are successfully demonstrated through a calibration experiment with different water levels.

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RD-014

Estimation of Mechanical Properties and Out-Of-Plane Cutting Characteristics of Thermal Printing Papers Using Several Mechanical Testing Methods

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Abstract

A thermal printing paper is widely used for sending a writing message by a facsimile machine and making a receipt sheet that is often seen in a daily general shop. The thermal printing paper is made of a hard-wood based paper material having the heat-sensitive upper layer which consists of a leuco dye and a developer. A white color of the heat-sensitive layer is chemically changed to a black color by sliding or pushing of a heating head against the heat-sensitive layer. This function of heat-sensitive layer is used for writing characters such as prices and purchase items on the surface of thermal printing paper. After printing out the purchase information, the paper is cut off by the zero-clearance guillotine-like cutter for stripping it safely. However, the cutting characteristics of well-used thermal printing papers were not yet revealed sufficiently. The cutting characteristics depend on the room humidity (and/or the water content of the paper), the room temperature and the mechanical properties (such as the thickness, the out-of-plane bending rigidity, the in-plane elastic stiffness, the out-of-plane shearing resistance and the in-plane yielding/breaking strength) of the raw paper material. Since the cutting condition of guillotine device must be adjusted for splitting the specified thermal printing paper, the zero-clearance and its back-up pressing force should be varied against the peculiar characteristics of specified paper and its environmental condition, generally. As a possible countermeasure, to investigate the cutting characteristics and any limitation or failure behavior of specified paper by using a chosen cutter condition is considered. Therefore, four kinds of widely used thermal printing papers were prepared for examining some benchmark tests. In order to investigate the cutting characteristics of the papers, a 2 dimensional (cylindrically symmetric) punching/shearing test, a plunge-cutting/dinking test, and the in-plane tensile testing were synthetically investigated.

RD-015

Investigation for Ignition of Green Monopropellant with Electrolysis and Pulse Laser

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We performed laser ignition experiment of green monopropellant with electrolysis for spacecraft. In conventional monopropellant thruster of spacecraft, hydrazine is used as propellant and catalytic ignition system is employed. However, it is dangerous to handle hydrazine because it has high toxicity. Furthermore, in catalytic ignition, a catalyst tends to be deteriorated by the high temperature and high oxidation atmosphere caused by combustion of green monopropellant. Recently, the study on green monopropellant attracts attentions for improvement of safety, performance and saving cost in operation of a thruster. Moreover, it is expected to apply a microchip-laser to spacecraft in the future.

In the previous study, laser irradiation was applied to droplets of SHP 163 at the experiment, and laser breakdown and gasification was confirmed. However, experimental pressure rise was approximately 20% of the theoretical value. This is because liquid droplets are scattered before laser energy absorption due to pressure wave generation by laser breakdown.

In this study, SHP163 gasification was performed to improve laser ignition efficiency and to evaluate its feasibility using electrolysis method. We report the electrolysis method which gasification has been confirmed as at 1.0mL SHP163, 1.0A current and 35.0V voltage with cupper electrodes, 120mm focal length convex lens and the pulse laser which has 532nm wavelength. Fig.1 is shown as a laser irradiation for gasified SHP163 using electrolysis method. We also confirmed that the pulse laser doesn't have any influence against the generated gas.

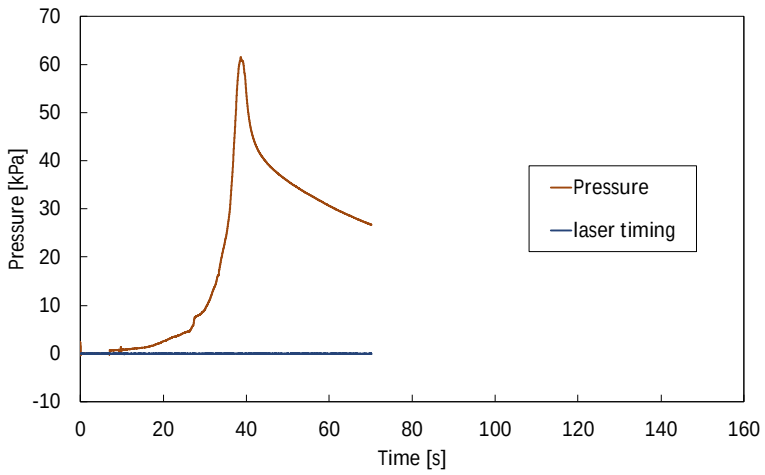

Fig.1 Laser irradiation for gasified SHP163 using electrolysis method

RD-016

Conversion of RPF Fly Ash Using Hydrothermal Synthesis

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Thermal recycling is one of effective method to reduce the quantity and mass of waste products. The refuse derived paper and plastics densified fuel (RPF) attracts for alternative fuels due to controllable and high calorific power, the carbon dioxide discharge reduction effect and lower ash content compared with coal. Because of these advantages, fuel is being converted from coal to RPF at the local thermal power station. In the case of large thermal power station, recycling technology has been established as most coal ash is diverted to other uses such as cement, concrete and roadbed material. Main components of coal fly ash are aluminum or silicon oxide and they are suitable as raw materials in the above applications. On the other hands, in the case of RPF fly ash, the main component is calcium-based salts which origin is paper. Therefore, it is difficult for RPF fly ash to apply the traditional fly ash recycling system and most of RPF fly ash are disposed to landfill with high cost.

We tried the phase conversion by hydrothermal synthesis for developing utilization method of unused resource of RPF fly ash. At first, we analyzed the condition of RPF fly ash by using TG-DTA, SEM, EDS and XRD. From the results of thermal dissolving behavior, main component of RPF fly ash is calcium carbonate ($CaCO_3$) micro-sized fiber (diameter is 1-10μm and length is more than 100μm.) And its surface is covered with nano-scaled impurities with indeterminate and easy to remove by simple pretreatment process; by making RPF fly ash slurry with bubbling air. After the water washing pretreatment process, the slurry was dried at 200 °C for 24 hours. And then, the pretreated RPF ash was sealed in the reaction vessel (HU-25, SAN-AI Kagaku Co. Ltd.) with pure water and heated from the room temperature in an electric furnace until it reached the target set temperature (200˚C maximum). After the reaction (60 minutes), the slurry was cooled to room temperature and filtered through a 0.45μm membrane filter. The solid products were dried at 80°C for 24 hours. The products were analyzed by SEM and XRD; most of products were $CaCO_3$ dissolution-deposition of source material and calcium, aluminum and silicon oxide mineral gehlenite ($Ca_2Al_2SiO_7$). We found existence kuzelite ($Ca_4Al_2(SO_4)(OH)_{12}\cdot 6H_2O$) from the XRD analysis at the condition of 200˚C which has been reported as an environmental material that can clear the environmental regulation value by reacting with heavy metal to form a hydrate.

RD-017

Imaging of Magnetic Domains by Magneto-Optical Kerr Effect Using Au Plasmon Filters

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Nd-Fe-B based magnets have been widely used in recent years as traction motors of hybrid electric vehicles and electric power steering motors. These magnets exhibit high coercive force. However, the coercive force decreased remarkably at high temperature. In-situ observation of the magnetic domains is an effective way to clarify the mechanism of the high coercive force because the magnetic properties of the materials significantly depend on the magnetic microstructures inside the materials. A magneto-optical Kerr effect microscope is a promising method to observe the magnetic domains because the dynamic observation is carried out easily under the magnetic fields. However, it is difficult to increase the sensitivity because it depends on the Kerr rotation angle of the magnetic materials. On the other hand, it has been reported that the Kerr rotation angle increases by the localized plasmon resonance that induces the electric field enhancement [1]. In our study, an observation of magnetic domains was carried out using a plasmon filter The sensitivity of the magnetic domains was evaluated by analyzing the contrast of the images. To date, we have already fabricated Au nanoparticle plasmon filters. However, the Au nanoparticles are not monodispersed because they were fabricated using self-organization of Au nanoparticles by annealing of Au thin films on SiO_2 substrates. In this presentation, we tried to fabricate uniform Au plasmon filters that consist of self-assembled SiO_2/Au core/shell nanoparticles. Then, the magnetic domains were observed using the filter.

Monodispersed SiO_2 nanoparticles with the diameter of 200 nm were self-assembled on SiO_2 glass substrates by dip-coating of SiO_2 nanoparticle suspensions. The withdrawal speed was 2 μm/s. SiO_2 nanoparticles were dispersed into deionized water and an amphiphilic block copolymer F-127 (Pluronic®). The concentrations were 3, 1, and 50 wt.%, respectively. Finally, Au thin film of ~30 nm thickness was deposited onto the SiO_2 nanoparticles on the substrates using sputtering method. Figure 1 shows a schematic illustration of an optical system for imaging of magnetic domains using the Au plasmon filter. The filter was put on an observed magnet.

Figures 2 were observed images of the magnetic domains without and with the Au plasmon filters. The image using the filter was obviously clear by comparing to the image without the filter. These results indicate that the increase of rotation angle was induced by the plasmon resonance enhancement. In the future, we will quantitatively assess the improvement by comparing the contrast of the images.

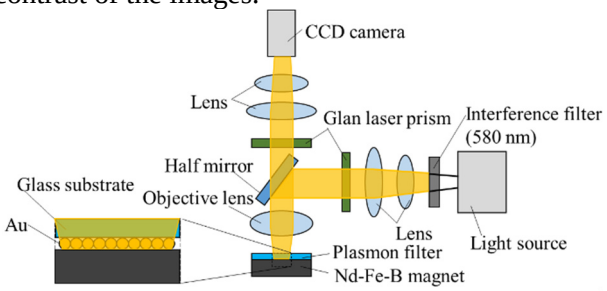

Fig. 1 Optical systems for imaging of magnetic domains.

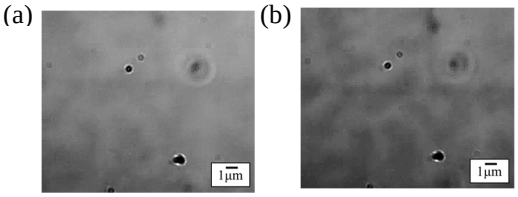

Fig. 2 Images of magnetic domains (a)without and(b)with Au plasmon filters.

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RD-018

New Phase Determination Approach for Displacement Measurement in Sinusoidal Frequency/Phase Modulation Interferometers

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Interferometer is a good candidate to achieve a high resoluatioin in displacement measurement. It has two light paths, one is a reference path and another is a measurement path. A phase difference between two arms corresponds to a displacement and the phase determination is an impotant to achieve high resolution in displacement measurement.Displacement measurement result is a traceable to metre definition, if light source would be stabilized.

A sinusoidal frequency modulation (SFM) and a sinusoidal phase modulation (SPM) have an ability to improve the resolution in the displacement measureing interferometer. A frequency/phase on the light source is modulated sinusoidal way and the interference signal generates harmonics of a modulation frequency. Conventionally, a conbination of a lock-in detection and lissajous diagram or a phase-locked loop (PLL) are used as the phase determination method. In these method, an one important parameter in interferometer, modulation index is treated as a fixed and a specific value which may vary in the actual measurement environment. This result a systematic error in displacement measurement result.

In this report, we introduce new approach for the phase determination method using both the PLL and a Bessel harmonic signal and discuss about how to generate the Bessel harmonics. There is a possibility to elliminate the systematicerror caused by the modulation index variation and to obtain both the modulation index and the displacement.

RD-019

Producing Aluminum Alloy / Copper Alloy Dissimilar Materials Joint Thin Plate by Using Friction Stir Welding and Rolling

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In order to realize a new structure and function, direct joining method of dissimilar materials has been studied. According to previous results, friction stir welding (FSW) is possible to make dissimilar materials joint such as steel and aluminum alloy, copper alloy and aluminum alloy, etc..[1] It is expected to add various functions like composite materials by joining materials with different properties. However, applying FSW to joint for thin plates is difficult. [2] In the present research work aims to develop a thin dissimilar materials joint plate produced with rolling process followed by FSW between aluminum alloy and various metallic materials and evaluate mechanical and functional properties of those joint plates. In this report, strength characteristics under static and cyclic loading condition in a dissimilar materials FSW joint between copper and aluminum alloy is studied. According to observation of cross section in the joint, the interface was clearly observed, and aluminum alloy and copper alloy were not mixed. Moreover, the interface was not perpendicular but tilted due to FSW and rolling processes. The joint was broken around edge of stir zone in tensile test and showed the similar strength of aluminum alloy base material. Fatigue strength test was carried out in the joint under tension-tension loading condition. The joint was broken around edge of stir zone as observed in tensile test under high stress amplitude condition. However, in case of lower stress amplitude condition, the joint was broken nearby the interface. Hardness in the stir zone was lower than that in aluminum base material. This reduction of hardness might be due to heating during FSW process. [3] [4] However, it was observed an increasing of hardness by applying rolling process. Therefore, it is speculated that the proposal method is an effective way to produce a dissimilar materials joint plate with high reliability in its weld region. Moreover, geometrical effect of the interface also possible to affect the strength characteristic of the joint.

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RD-021

Recycling of High Purity Magnesium Sheet from MG-AL-CA System Alloy by Vacuum Distillation and Extrusion

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Magnesium is lightweight, so has excellent mechanical properties, and application to various field is expected. Because magnesium is excellent in bio absorbability, it is expected to be used as a biomaterial in the medical field. However, commercial pure magnesium corrodes because included iron, nickel and copper. We need high purity magnesium to use it at long time.

The Mg-Al-Ca alloy is improved flame retardancy by adding Ca, and therefore is widely used for engine parts and the like. So In this research, it studied the recycling of high purity magnesium sheet from Mg-Al-Ca system alloy by vacuum distillation and extrusion method. Vacuum distillation was performed by 600℃ of raw material temperature and 360℃ of condenser temperature using magnesium alloy ingot MRI-153. It extrude in 375℃ of temperature and 49 of extrusion ratio using the magnesium deposit obtained vacuum distillation. Magnesium sheet were more than 99.99% of purity.

It investigated chemical composition, anisotropy of tensile properties and corrosion resistance of that magnesium sheet. Fe, Ni and Cu which adversely affect the corrosion was not included in the magnesium sheet. The ultimate tensile strength at the specimen was the largest in the direction of 45 ° and the elongation was the largest in the direction of 0°. The corrosion rate of the magnesium was less than 1.0mm/y. The average crystal grain size is 53.4μm, and the crystal direction is the (0001) direction.

RD-022

Change in Mechanical Property of Resin Materials Due to Heat Treatment and and Its Effect on Interfacial Strength of Dissimilar Materials Joint Between Resin and Metal

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The dissimilar materials direct joining between resin and metal has been developed such as laser joining, ultrasonic welding and friction stir heating, etc. Mechanical properties of the resin are possible to change due to heating during those joining processes. Moreover, the joint between resin and metal is used under high-temperature condition, heat cycle condition and high humidity condition. It was reported that those environmental conditions affect the joining strength [1]. The strength of the dissimilar materials joint can be affected by change in interfacial strength itself and the change in the mechanical property of resin too. In this study, the effect of heat treatment on the mechanical property of resin material and effect of the change in mechanical property of resin on the interfacial strength of the dissimilar materials joint were investigated. Tensile strengths of resin materials, Polyamide 66 (PA66), Poly Ethylene Terephthalate (PET) and Polyphenylene Sulfide (PPS) were affected by heat treatment with temperature of 140℃. In case of PA66 (Polyamide), the tensile behavior changed significantly from ductile to brittle with an increase of heat treatment time. According to FT-IR result, chemical bond might be changed after the heat treatment. Indentation test by using a wedge shape indenter was conducted to evaluate the interfacial strength of the dissimilar materials adhesive joint between PA66 and A5052. In order to study effect of the change in mechanical property of resin on the interfacial strength, PA66 with and without heat treatment were used for adhesive joint. The maximum load corresponding to delamination of the interface changed by applying heat treatment to the resin. Therefore, it is speculated that interfacial strength changed by the change in mechanical property of resin.

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RD-023

Proposal on Interference Signal Extraction Filter in Pulse Train Interferometer

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In July 2009, the national standard tool for measuring length in Japan was changed from iodine-stabilized helium-neon laser to femtosecond optical frequency comb. We are required a length measurement method compliant with a new standard. The method using adjacent pulse repetition interval length was proposed.

We automatically decide the filter using the fact that the envelope peak and the phase crossing point coincide in this research. After the filtering process, when the envelope peak and the phase crossing point coincide, it is evaluated that the processing is performed with the correct filter. Apply this method to the waveform obtained from the experimental device and confirm that this method is useful.