Evaluation of Power LED Modules for Photomorphogenesis in Plants

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Keywords : LED, light, plant, photosynthesis, photomorphogenesis

Power LEDs are convenient tools to study photomorphogenesis in plants. LED modules, such as plant exposure lighting, are easily constructed using power LEDs. Emission spectra of LEDs are narrow bandwidth with peak wavelength. It is possible to isolate the effects of specific photoreceptor systems in plants with these spectra.

In order to cultivate plants under the LED light, some LED modules were assembled in laboratory. Figure 1 shows such LED module, composed of red and blue LEDs. The size of the module is $95 \times 291 \times 3 \text{ mm}$. Figure 2 shows an electric circuit of the module. Red and blue spectra are suitable for development of plants. The ratio of blue and red light is 0.64 (B/R = 0.64). B/R ratio as 0.35 modules were also assembled.

Figure 3 shows an another electric circuit of the LED module, composed of yellow, red and blue LEDs.

Figure 4 shows the position of the LED modules and plants. B/R = 0.64, B/R = 0.35 and Y/B/R modules were mounted in each section. At the top of the plant, photosynthetic photon flux (PPF) was setting at 150 µ mol m$^{-2}$s$^{-1}$. Results of indoor cultivation experiments under different light are showed in Fig. 5 and Fig. 6. These results indicate that the specific photoreceptor systems exist in plants, since specific spectra of light changes the shape of the plants.

Fig. 1. LED module (making for trial manufacture)

Fig. 2. Electric circuit of the LED module (Blue/Red)

Fig. 3. Electric circuit of the LED module (Yellow/Blue/Red)

Fig. 4. Position of the LED modules and plants

Fig. 5. The comparison of two lettuce ($L. s. \ var. \ crispa$); Same lettuce but different light, (a) B/R = 0.35 (b) B/R = 0.64

Fig. 6. The comparison of two lettuce ($L. s. \ var. \ capitata$); Same lettuce but different light, (a) B/R = 0.64 (b) Y/B/R
Evaluation of Ultrasonic Wave Generation using Electromagnetic Acoustic Transducer with Current Driven Circuit

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Keywords : ultrasonic wave, electromagnetic acoustic transducer, current driven circuit, pulse forming network

The non-destructive inspection technique using ultrasonic waves, generated by an electromagnetic acoustic transducer (EMAT), has been introduced into the in-service inspection of fast breeder reactors. The EMAT allows us to inspect the defect without any contact material between the transducer and a test sample at the temperature of about 200 ºC. However, the ultrasonic signal propagated in a test sample has a fault of low signal to noise ratio. In these circumstances, a proposal has been made of a new EMAT driven by a pulse current method.

Figure 1 shows a cross section of the proposed EMAT, which consists of two types of coils. One is a transmission coil producing the eddy current in the conductive sample by applying high frequency current. The other is a thin film circuit introduced in place of the permanent magnets. If there is continuous electric current flow in the thin film circuits in order to generate the static magnetic field such as the permanent magnets, the film circuits immediately heat up. Therefore the current passing through the films is produced only when an ultrasonic wave is transmitted. A pulse forming network (PFN) circuit which can generate a large pulse current is selected for the power supply applied to the EMAT. In this paper, the magnetic flux density generated by the current driven EMAT with respect to the film thickness and the number of the film layers is evaluated using numerical calculation method. The directivity of ultrasonic wave corresponding to the time variation of the current is also estimated.

Figure 2 shows the magnetic flux density related on the voltage per layer where the film circuits are stacked from one layer to twelve layers. Here, the voltage per layer is calculated from the discharge voltage divided by the stacked layers. For all films, the voltage per layer is decreased and the magnetic flux density is increased as the number of the stacked layers is increased. However the increment behavior of the magnetic flux density is quite different with the thickness of the layer. High magnetic flux density above 2 T may be achieved by multi-layers stacked up the conductors with 50 µm in thickness as the current circuit. This estimated value is much larger than that generated by the EMAT with the permanent magnets. Because the discharge voltage of the PFN circuit is increased with increasing the impedance of the film circuits, larger magnetic flux density may be easily obtained for the case of the thick layer.

The time variation of the current passing through the conductive layers depends on the characteristic impedance of the pulse forming network circuit. For the larger value of the characteristic impedance compared with that of the internal resistance, the rectangular current was nearly obtained as a function of time. In contrast, the current was exponentially decreased for the lower characteristic impedance. Figure 3 shows the variation of sound pressure relative to the average current. Here, the average current is estimated from the average value of the current for the duration of the ultrasonic wave generation. The sound pressure at the detect point change linearly corresponding to the average current.
Actual Example of Reflection on Training, Technology Transfer, and Engineering Education Regarding to Power and Energy Equipment

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Keywords : power and energy paper, surge arrester, engineering education, design and drawing of electric equipment, technology transfer

1. Introduction

Engineering Education is very important from the viewpoint of the technology transfer and the development of the new technology. What methods are expected on Engineering Education regarding to power and energy equipment”?

In 2009, the author has reported impression responses of young students by using IEEJ transaction and essays for developed power equipment consisting of Circuit Breakers, Large Transformer, Adjustable Speed Generators, 1100 kV Transmission Lines, HVDC 125 kV – Upgrade 500 kV Converter Stations, analyzed program EMTP (Electro-Magnetic Transient Program) and Surge Arresters on engineering education as shown in the IEEJ trans. PE, Vol.130, No.8, 2010.

This paper describes actual examples of sense and reflection of students under learning Design and Drawing of Electrical Equipment using hybrid texts. Those hybrid texts are combined with IEEJ papers and articles described recent social conditions and human experience to motivate educate engineering as shown in No.1 – No.6.

No.6: Complement Articles that described Recent Social Conditions and Human Experience: “First Submitted Paper, did not accepted” from the Interview of Nobel Prized Dr Suzuki, “Restart of Manufacturing –Semiconductor–”, “Globalization on your Foots”, “Negotiation over the Night”, “Creativity on Integrating Normal Culture under Continuous Basic Effort”, and “Reservation of Social Safety depending on Adequate Renewal Work for Power Equipment”

Reaction comments of young university students have been obtained from the themes asking questions on the above hybrid texts. Expressed comments show the good sense on the point of the view of the technology transfer and the development of new technology.

After investigation, this paper describes sense and reaction of students, and reflection under learning Design of Electric Machine and Drawing of Electric Equipment by developed hybrid texts in 2010. From this trial, it is understand that the developed hybrid texts are useful for the engineering education of the power technology.
Amplitude Statistics of Ground Clutter from Town and Hill Observed by an S-band Radar

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Keywords: S-band radar, ground clutter, compound distribution, AIC

We have observed ground clutter from town and hill using an S-band radar, which is located on the campus of the National Defense Academy in Yokosuka-city. The characteristics of the S-band radar are shown in Table 1. We observed around the city hall of Futu-city at 16:07 October 15, 2009. It was cloudy. The observed data is shown in Fig. 1. This data is a region of 256 range sweeps in azimuth interval and 256 range bins in range interval.

To determine such ground clutter amplitude statistics, we introduce the Akaike Information Criterion (AIC). We investigate the compound log-normal, compound Weibull, and compound log-Weibull distributions using this AIC.

We have found that ground clutter amplitude obey the compound log-normal distribution with the shape parameters of \( \sigma_1 = 0.424 \), \( \sigma_2 = 0.232 \) for entire data and the compound log-normal, and compound log-Weibull distributions with the shape parameters of \( \sigma_1 = 0.217 \) to 0.429, \( \sigma_2 = 0.028 \) to 0.410 and \( c_1 = 9.36 \) to 11.20, \( c_2 = 17.00 \) to 23.81, respectively, for data within the beam width of an antenna. The number of the smallest AIC (MAIC) of the compound log-normal, and log-Weibull distributions are 8, and 4, respectively. Two typical samples are shown in Figs. 2, and 3.

Table 1. S-band radar characteristics

<table>
<thead>
<tr>
<th>TOKIMEC BR-3440 MA-S314</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>frequency</td>
<td>3.05 GHz</td>
</tr>
<tr>
<td>transmitted peak power</td>
<td>30 kW</td>
</tr>
<tr>
<td>pulsewidth</td>
<td>1.0 µs</td>
</tr>
<tr>
<td>pulse-repetition frequency</td>
<td>800 Hz</td>
</tr>
<tr>
<td>antenna length</td>
<td>14 ft</td>
</tr>
<tr>
<td>antenna scan rate</td>
<td>22 r.p.m.</td>
</tr>
<tr>
<td>horizontal antenna beamwidth</td>
<td>1.8°</td>
</tr>
<tr>
<td>vertical antenna beamwidth</td>
<td>25°</td>
</tr>
<tr>
<td>polarization</td>
<td>horizontal</td>
</tr>
<tr>
<td>receiver</td>
<td>linear</td>
</tr>
<tr>
<td>intermitted frequency</td>
<td>60 MHz</td>
</tr>
<tr>
<td>intermitted bandwidth</td>
<td>5 MHz</td>
</tr>
</tbody>
</table>

Fig. 1. Observed data

Fig. 2. Compound log-normal distribution is best fit to data for range sweep 21 \(\sim\) 41

Fig. 3. Compound log-Weibull distribution is best fit to data for range sweep 168 \(\sim\) 188
Extended Summary

Review of Current Situation and Problem towards Global Earthquake Detection using Satellite-borne Microwave Radiometer

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Tadashi Takano Member (College of Science and Technology, Nihon University)

Keywords: rock failure, microwave radiometer, data processing, earthquake detection

Five years have passed since our research team discovered microwave signals generated by rock failures in a laboratory experiment for the first time in the world. Figure 1 depicts the flow of our research plan.

As shown in this figure, since then, we have theoretically investigated the mechanism to generate rock failure microwave signals, performed a field experiment to detect rock failure microwave signals in association with actual rock cliff collapses, and developed a data analysis method to extract local and faint microwave signals emitted from the ground from the data of a microwave radiometer, the Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E) aboard the Aqua satellite, in order to realize global earthquake detection. As a result, we obtained positive results at each phase of our research plan. In particular, in the latest phase shown in Fig. 1, we first demonstrated the capability of our developed analysis method through the incident of a volcanic eruption, and then indicated that characteristic microwave signals were emitted from the area where seismic activity deformed the land surface with respect to some large earthquakes. However, at the same time, these results have revealed some problems to be solved before we can move our methodology closer to practical use.

In this paper, we review the results obtained in AMSR-E’s data analysis phase and summarize the current problems to be solved.
LSI Design Education with Prototype Chip and IP Database

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Kousuke Tanaka  Non-member (Hiroshima Institute of Technology)
Takeshi Tanaka  Member (Hiroshima Institute of Technology)

Keywords : prototype chip, IP database, LSI design education, Integrated circuits, coursework

As manufacturing technology has advanced in recent years, LSI design education has become more important. In some universities, FPGA chips are used to educate computer systems and microprocessors instead of fabricating LSI chips. However, the inside of FPGA chip is sometimes regarded as a black box by students and it is not connected to the knowledge of MOS FET and CMOS gate structures in the field of semiconductor processes. Then students may not understand the relation between the areas of semiconductor processes and LSI design.

In Graduate School of Engineering, Hiroshima Institute of Technology, we have been teaching “Advanced System Development Technology of Integrated Circuits” as a coursework. Since 2009, we have introduced a prototype chip into the coursework where students draw layouts of half adder, full adder, and 2-bit adder in order to understand the relation between the areas of semiconductor processes and LSI design.

In addition to this, we have introduced an IP database into the coursework, where IP (intellectual property) means circuit diagrams or circuits written in HDL (hardware description language) which are already designed and verified. In order to refer the circuits written in a various descriptions such as VHDL, circuit diagram, etc., we collected those IP, constructed an IP database (see Fig. 1), and introduced into the coursework.

In the semiconductor process area, clean room experience at Hiroshima University and invited talk by a lecturer from Texas Instruments Japan have been conducted in addition to the lectures on the outline of LSI design, MOS transistors, and fabrication processes.

In the LSI design area, students design calculators with SystemC. Some students are unused to designing circuits with HDL such as VHDL or Verilog HDL. SystemC is based on C++ which all students learned as undergraduate students. We have not aimed at the acquisition of the grammar of SystemC, but aimed at the experience for the students to design circuits with HDL. The designed calculators are tested by the FPGA board.

In order to understand the relation between the areas of semiconductor process and LSI design, we have introduced a prototype chip into the coursework. Students draw layouts of half adder, full adder, and 2-bit adder by IC layout system IZUMO. The chip size is 3.4mm × 3.4mm, and 1.2um rule (see Fig. 2).

Fabricated chip is verified by using logic analyzer. The inputs were generated by the slow clock, and the outputs were tested. Then using the faster clock, we analyzed the delay of circuits.

In order to verify the effectiveness of the prototype chip and IP database which are introduced into the coursework, we conducted a questionnaire survey for 3 students in 2009 and 8 students in 2010. By this questionnaire survey, the effectiveness of both prototype chip and IP database is verified. Future research includes revision of the course schedule in order to spend more time on glitches or latency countermeasure, etc.
Study on ESD Phenomena of Magnetic Head by 1ns Pulse ESD

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Keywords : ESD, EMI, GMR head, damage

GMR (Giant Magneto Resistive) heads, the most electrostatic discharge (ESD/EOS) sensitive device of all electric devices, are used for high density magnetic recording applications. Figure 1 shows the structure of a GMR head. An Anti-Ferro magnetic layer (AFM), a pinned layer, and a free layer are stacked up, and domain control layers are fabricated on both sides of these three layers. The resistance of the GMR element varies according to the magnetic field from disk. A number of problems related to electrostatic discharge phenomenon in GMR heads have been reported, including melting and diffusion caused by the Joule heating by ESD currents, pinning rotation and demagnetization resulting from high magnetic field strength, and dielectric breakdown induced by high voltage. Also, as in some previous work, we also found that ESD current leads to head amplitude degradation and instability. The major evaluation methods use ESD waveform such as the HBM (Human Body Model), the MM (Machine Model), and the CDM (Charge Device Model). Many researchers have been implementing ESD studies of GMR head, such as its destruction mechanism by ESD waveform analysis.

In order to increase the recording density of HDD, the GMR sensor layer needs to become smaller with read track width and stripe height becoming about 100 nm. Recently, as the devices become increasingly smaller, there has arisen a concern for damaging GMR heads by EMI. The potential impact of the EMI events on GMR heads has been pointed out.

CDM or nano second pulse ESD is key issue for Magnetic head manufacturing. It is important to improve the ESD robustness and magnetic stability.

In this paper, ESD robustness of pinned layer was studied for GMR heads by using high field QST with nano pulse ESD simulator. We investigated the degradation of pinned layer with anti ferro materials, we made the following findings:

1. Damages to the Pinned layer were caused by nano pulse ESD.
2. Pinned layer damage types were categorized using high field transfer curve. High-field transfer curves of GMR heads after applying ESD damage change from Normal type to Fuji, Butterfly or Hysteresis etc.
3. Analysis of these damaged heads in magnetic state suggested that Joule heat and extra magnetic field from ESD would degrade the interlayer exchange coupling between a pinned layer and an Anti-Ferro magnetic layer.
4. It is difficult to observe the magnetic behavior of pinned layer using usual QST tester. Nonetheless, high-field (~10 kOe (about 800 kA/m)) QST tester makes it possible.
5. GMR heads degradation phenomenon, such as decrease in amplitude and amplitude flipping, can be understood by the ESD damage to magnetic behavior of a pinned layer and an Anti-Ferro magnetic layer. Therefore, high field QST is useful for analysis of ESD damaged heads.

It is very important to study the performance of the pinned layer to understand the magnetic instability of GMR head.

Fig. 1. Structure of a GMR head

<table>
<thead>
<tr>
<th>Type-1</th>
<th>Type-2</th>
<th>Type-3</th>
</tr>
</thead>
<tbody>
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<td><img src="image2.png" alt="Graph" /></td>
<td><img src="image3.png" alt="Graph" /></td>
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</tbody>
</table>

Fig. 2. Results of High field transfer curve before and after ESD was induced
Study on Molecular Behavior in Oxidation of Insulating Oil using Terahertz Spectroscopy

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Satoshi Matsumoto  Senior Member  (Shibaura Institute of Technology)
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Keywords : terahertz, absorption characteristics, insulating oil, oxidation, molecular behavior, hydrogen bond

Insulating oil has been used as an insulation material for HV equipment such as transformer, power capacitor and cable. The total number of aged power equipment increases because of the economical reason and the development of diagnostic techniques to maintain the equipment reliability is needed. Therefore, it is important to clarify the insulating characteristics of the deteriorated insulating oil.

This paper describes the molecular behavior in oxidation of insulating oil using terahertz spectroscopy. Terahertz wave has high sensitivity to intermolecular interaction because it operates in lower energy region than infrared ray. In this study, the molecular behavior of heated insulating oil was investigated by using simulated oxidation process samples. The samples were prepared by mixing 2-octanol and dodecane in the following 2-octanol ratio; 50, 33, 20, 10, 5.1, 2.7, 1.3 and 0.18vol%.

Figure 1 shows the absorption coefficient spectra of the mixed samples. The absorption increased around 6.73THz and 12THz or more as the concentration of 2-octanol increased.

Figure 2 shows the change of absorption coefficient at 6.73THz, 13.5THz and 14.7THz, respectively. The broken lines show the ideal changes calculated from 2-octanol absorption on 0.18vol% spectrum, which has the smallest influence on interaction. These broken lines were drawn in accordance to Lambert-Beer laws. In the figure, the plots of 13.5THz and 14.7THz were linearly changed and accorded with broken lines. On the other hand, the plot of 6.73THz was nonlinearly changed as a curve shape plot is observed. This result means that the molecular vibration was suppressed by intermolecular interaction.

Figure 3 shows the calculated intensity spectrum by molecular orbital method. As a result, the absorption peak appeared around 6.7THz was originated from vibration of OH group. OH group has a strong polarity and results in hydrogen bonds. Then, it is believed that the absorption change at 6.73THz was influenced by hydrogen bonds. This phenomenon was also observed in heated insulating oil.

Therefore, this region is useful for an index of the progress degree of the hydrogen bonds.
Research of Carbonyl Iron Powder for Development of the Power Inductor for High Frequency

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Hiroyuki Ono  Member  (TDK Corporation)
Tomokazu Ishikura  Member  (TDK Corporation)
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Keywords: inductor, dust core, carbonyl iron powder, nanocrystalline soft magnetic materials

We have investigated the carbonyl iron powder (CIP) for development of the low-loss power inductor at about 1 MHz. Significant differences were observed for the coercivity between two kinds of CIP (Non-reduction CIP and Reduction CIP). Coercivity of Non-reduction CIP is 2.5 Oe and one of Reduction CIP is 10.7 Oe. In order to investigate the origin of significant differences for the coercivity, we have studied two kinds of CIP.

Figure 1 shows XRD pattern for two kinds of CIP. Non-reduction CIP showed a broad XRD pattern, suggesting that the fine crystal grains.

Figure 2 shows cross-sectional STEM images for two kinds of CIP. One particle is composed of several crystal grains in reduction CIP. Non-reducing CIP is suggested that consists of a large number crystal grains of about 20 nm.

As a result, it was shown that Non-reduction CIP with low-coercivity is Fe-based nanocrystalline soft magnetic material with high saturation magnetization. We could produce a low-loss dust core using low-coercivity CIP at about 1 MHz.

Fig. 1. XRD pattern of carbonyl iron powder

Fig. 2. Cross-sectional STEM images of carbonyl iron powder
Improvement of Photo-functional Properties of TiO₂ Thin Film Coated by W Surface Layer

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Keywords : TiO₂ thin film, W coating, reactive sputtering, photo-functional property

1. Introduction

Titanium oxide (TiO₂) has considerable properties such as photocatalysis, dye-sensitized photovoltaic effect, photoinduced hydrophilicity and a transparent electrode. Also the photocatalytic property of TiO₂ has antifouling effect and ability to decompose environmental pollution materials such as nitrogen oxide etc. it is expected to use as an element of a clean energy system in future. However, TiO₂ has a wide band gap (3.0-3.2eV) so that the higher photocatalytic effect occurs under UV irradiation. In order to improve photofunctional properties under visible light, many researchers have dope metal or gas into TiO₂.

In this study, the reactive magnetron sputtering system was used to fabricate TiO₂ thin film. Tungsten (W) was formed on the surface of TiO₂ films at 0.4-2.5nm in thickness. By adding W layer to TiO₂ thin film surface, tungsten oxide is generated, this oxide plays a main role to shifts the conduction band of TiO₂ to the positive side. Because the motion energy of each electron becomes smaller, excited electrons in a visible region increase and promote the photocatalytic reaction in this region. The difference in the band gap of WO₃ (2.8eV) and TiO₂ (3.2eV) encourages the electrons to move from a valence band to conduction band as shown in Fig.1, so that the free electrons increase in film surface. The photocatalytic property of W-TiO₂ thin film which was evaluated by a methylene blue immersion test had been improved under artificial sunlight irradiation.

The mirror finishing stainless steel (304ss) and corning glass (#1737) was used as the substrate for TiO₂ thin film. Ti was deposited by using RF magnetron sputtering source under a deposition rate of 0.025nm/sec at 20sccm in an Ar gas flow rate. An O₂ gas was inlet to the chamber under 1.5sccm in a flow rate. After forming TiO₂ film at 200nm in thickness, W was sputtered by using a DC magnetron sputtering source in Ar plasma under 0.001nm/sec in a depositing rate. W was formed on the surface of TiO₂ thin films at 0.4-2.5nm in thickness. All samples were formed under a substrate temperature of 200 °C.

Photocatalytic property was investigated by soaking a sample with an area of 100mm² in a methylene blue solution of 10 ppm in the concentration. By using a commercial sterilization lamp and an artificial sunlight lamp with ultraviolet filter, UV and visible light was irradiated to the sample. Change of a decolorized methylene blue solution was measured by a spectrophotometer at regular intervals.

Figure 2 shows transmittance at wavelength with 664nm of methylene blue for W layer thickness under 6 hours of sterilization and artificial sun light irradiation. W was indicated at a metal or/and oxide mode on surface depending on W layer thickness. The photocatalytic property was enhanced under artificial sun light by adding W to the surface and the maximum photocatalysis of the W coated TiO₂ thin films were improved by 4 points in the sample with W layer thickness of 1.7nm.