Innovation and Development in Education

Master of Education Policy and Development
Muhammadiyah University of Malang Indonesia

Musa Asiah Foundation Cambodia

Saturday, April 27, 2013

Published by:
Master of Education Policy and Development
Postgraduate Muhammadiyah University of Malang-Indonesia

ISBN : 978-979-796-258-6

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Preface

Strenghtening the quality of education can be realized through innovation and development of education. A model development in accordance with materials taught covers strategies, approach, and method implemented in the learning process. Various models have been developed as a trend to improve learning quality, including learning media, the integration of materials which fit to the learning condition, long-distant learning, and a web-based learning. This international seminar on education discussing innovation and development about education with concept or development implementation in education

This International Seminar on Education, a cooperation between the Postgraduate Program of the University of Muhammadiyah Malang Indonesia and Musa Asiah Foundation of Cambodia is intended to study any issues concerning with strengthening teacher professionalism thorugh an interdisciplinary approach. This seminar is appropriate and can give some chanches to share ideas useful for improving the quality of education.

Selangor, April 27 2013
Editor

Content

Preface iii

Content v-vi

Problem Solving in Mathematics 1-5
Akhsanul In'am

Implementation of Think-Pair Share Model to Improve The Ability Process and The Learning Achievement of The Electric Static Concept of The Ninth Grade Students of SMPN 7 Tarakan 6-9
Amat

Islamic Education Curriculum 10-13
Aminullah Malik Katamsi Afandi

Increasing The Effective Speed Reading using Tri Focus Steve Snyder 14-17
Dian Maulina

The Effect of Teams Games Tournament Strategy, Gender and Intelligence to Learning Achievement 18-22
Dwi Riyanto

The Paradox on IT Literacy and Science's Learning Achievement in Secondary School 23-26
Dwi Sulisworo

Self Medication in Yogyakarta: Proportion And Predictors 27-30
Dyah Aryani Perwitasari, A Sakina

Instructional Program Evaluation Model 31-33
Eko Putro Widoyoko

Character Education Based on Language and Literature 34-38
Eny Hartari

Mental Health Psycho-Education As A Preventive Action To Realize Holistic Health Community 39-44
I Dewa Ayu Eka Dharmatari

Professional Practice Report Case Receptive-Expressive Communication Disorders 45-48
Ida Sriwaty

A Group Case in Unit Pasaraya Cebongan (Implementation of Management Conflict Training) 49-52
Indriani

Developing Learning Worksheet Using 7e Cycle To Enhance Learning Achievement And Critical Thinking Skills 53-56
Irma Rosa Indriyani

Preliminary Study of Competitive Learning Model Ff-CURE in The Mathematics Learning 57-60
Jero Budi Darmayasa

Gobak Sodor Games To Improve Student's Motivation on Learning Mathematics 61-71
Kustiningsih

Fire Alarm Equipment as A Tool To Improve Student Critical Thinking Skills 72-75
Mahmudah

Web Based Interactive Learning Media to Improve Learning Achievement 76-79
Masdi Saleh

Obtaining The $Ni_{80}Fe_{20}$ Thin Film Smoothness Through The Capasitance Value Of Film In The R-C Serial Device 80-86
Moh Toifur

Islamic Counseling, An Intervention Model To Value Crisis 87-89
Muhammad Japar

The Role of Leader on Implementation of Quality Based Education 90-92
Nurmala Widyasari

Using Group Investigation Technique to Enhance Learning Achievement on Physics Education 93-97
Nuryanto

Developing Children's Autonomy Through Family and Preschool Education 98-102
Purwati

E-Learning Effectiveness to Improve Learning Achievement on Physics Learning At Senior High School 103-105
Sri Puji Agustin

Implementation of Cooperative Learning Quiz-RT Students Class IX Junior High School 01 Batu 106-111
Suharlik

A Contrastive Study Between Bugisness and English In Adjectives of Comparative Degrees 112-114
Suparman

The Concept Character Building in The Javanese Society 115-116
Suradi

ICT Based Learning Media to Improve Education Quality 117-120
Suwartini

Optimizing The Understanding of Mathematics Content Using Learning Model "Barter" 121-124
Sri Teguh Lestari Saptarini

Problem Based Learning Model to Promote Critical Thinking 125-128
Tusino

Developing Computer Based Multimedia Instruction for Fundamental Concepts of English Speech for Junior High School Students in Tarakan 129-136
Winarno

Obtaining The $Ni_{80}Fe_{20}$ Thin Film Smoothness Through The Capasitance Value Of Film In The *R-C* Serial *Device*

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Abstract: Capacitive properties of $Ni_{80}Fe_{20}$ thin film as the result of sputtering on the various deposition field (B_{dep}) from 0 up to 600 G was reached. The aim of the research is to determine the smoothness of film with investigating the capacitance due to film porosities, and the performance of film as low pass filter. Device constitute of the resistor R = 769.9 Ω serially connected with a film. Device was supplied with AC voltage from AFG. Investigating the capacitive properties was done on the 100 kHz frequency, while investigating the cut-off frequency was done in the range of 100 up to 1000 kHz. The output and input voltage were investigated through oscilloscope. From investigating the capacitive properties show that all samples display capacitive properties. The lowest capacitance according to the sample resulted from deposition on the B_{dep} of 300 G that is 0.09 pF, which is show the smoothest film compared with others.

Key words: capacitance, sputtering,

Research on surface roughness is mostly done in the fields of industry, including electronic material industry, metal and rock. Investigation of smoothness of the surface traditionally is determined by using the stillus which the results is stated in the average value of the rise and fall of the surface plus the deviation. Stillus method is further developed techniques such as computerized readings (F Luk, 1989) determination of error becomes more absolute by negating the roughness of reference (Katherine, 1990), the method of data collection is not only in the horizontal direction but also in combination with the vertical direction (Ulf, 2006) .

Nevertheless stillus methods has several disadvantages such sample surface becomes deformed, long time, construction is complicated, expensive, need people who are skilled to operate (Bogdan, 1986). The goodness of the results also depends on the cross-sectional end stillus (M Diederich, 2009). As in complaining by Propoat (Ersin, 2010). for a sample of rock it is required an information where surface part of the continuous and discontinuous parts are. This method is often found substantial errors. The next development was reading surface roughness based on optical methods. In the optical method, the beam used is a laser beam [7,and x-ray (SH Wang, 2000, Lisa, 1998), beam can be directly on the sample surface or guided by fiber optics without contact to the sample (J Valicek, 2012).

Data taken from intensity of reflection light (Miho, 2010). More rugged material will have a reflectivity curve to angle 2θ, steeper than the materials that are less harsh. This method was developed further and was able to show the intensity of each point on the surface of the samples according to the depth (Anayet, 2011). Mazule developed a method of total integrated scattering (L Mazule, tt). Similarly, the images obtained in 3-D, where the resulting image is a combination of light microscopy and regulating lighting on the computer (Ossama, 2010). This method has several advantages including non-contact, real time, clear and accurate so very suitable if it is used in metal (Govindan 2007, Zahide,1999).

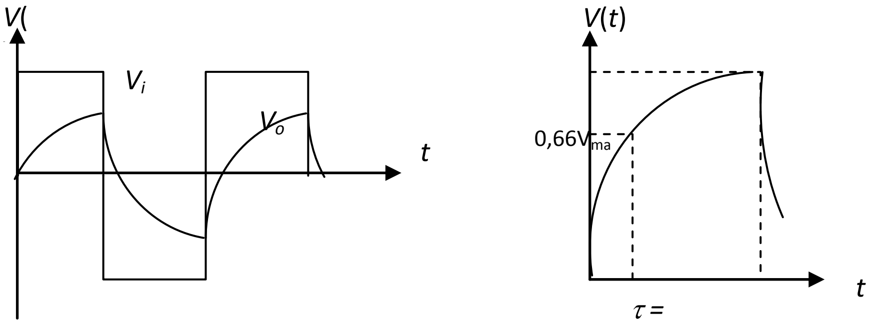
In this paper, we will display a completely different method to the methods that have been developed by previous researchers. We know that, in a smooth film it was not found or contain only slight porosity because the atoms are homogeneity spread on each location on surface of the substrate. In contrast the rough film contains lot porosities. Porosity can be seen as small cavities micron-sized or smaller. If the film is from conductor (both magnetic and non-metallic magnetic), the presence of porosity may interfere to the conducting process of electrical current so the conductivity of film deviates from the normal. For very thin films, the presence of porosity can be transparent so it can be observed using a tool as optical microscopy.

If a film containing porosity on both sides is supplied with a voltage source, either DC or AC, the cavity that adjacent to the positive pole will have positive potential more than the cavity adjacent to the negative pole. As a result, the electrical current will flow from the positive pole toward the negative pole. If the flowing of electric current strike the cavity, apart of the current will take another route out of the cavity and apart of them occupy the two side of cavity as the surface charge. As a result, this cavity can role as a capacitor and the medium in the cavity acts as a dielectric. Film having a lot number cavities or have the large size cavity has a large capacitance, while in contrast on a film which has a fewer and a smaller cavities will has a small capacitance.

This paper will discuss determining the value of the capacitance of permalloy thin film ($Ni_{80}Fe_{20}$) as a results of sputtering on various deposition field. The estimation that the film has a capacitive character was tested by using a serial RC circuit which is connected to AC voltage source from AFG (Audio Frequency Generator) in the squarewave form with a frequency that can be set. Output voltage is displayed visually through CRO screen. If the output voltage of film is the triangle wave the film is capacitive properties. Furthermore, the value of C can be determined by two ways that are from value of a fitting constant B that is equal to $1/RC$ if data (t_i, v_i) is fitted according to the $y = Ae^{-Bx}$ where $x = t$ and $y = V$; another is from the time constants $\tau = RC$ corresponding to the voltage $V = 0{,}66V_{\max}$ on the V vs. t curve.

Theory

1. Character of capacitive film



(a) (b)

Fig. 1. (a) Response of capacitor voltage (V_o) of the square wave input voltage (V_i). (b) Graph of V vs. t and $\tau = RC$ position corresponding to $V = 0.66\ V_{\max}$

If on electrical circuit containing a capacitor is supplied by square wave voltage, then output voltage in capacitor is no longer the square wave but there is a reduction to a triangular wave. This reduction is due to the event charging and discharging on the capacitor. The curvature mode of input and output is as shown in Fig. 1. The equation for the output on capacitor is:

$$V_o(t) = V_{\max}\left(1 - e^{-t/RC}\right) \tag{1}$$

Where t = time, R = resistance, C = capacitance, $V_{\max}$ = The maximum voltage. On $t = RC$ or commonly referred to as the time constant, τ, so eq. (1) becomes:

$$V_o(t) = 0{,}66V_{\max} \tag{2}$$

2. Serial RC circuit

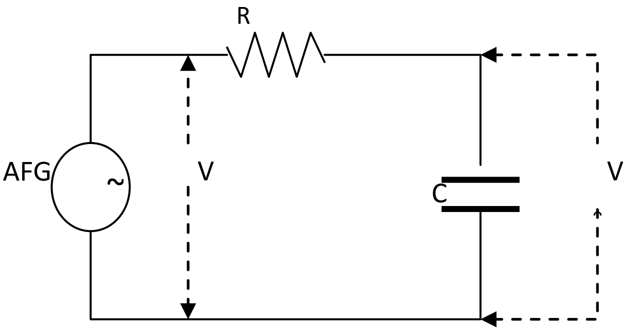


Fig. 2 Serial RC circuit

Serial RC circuit is shown in Fig. 2. In practice, component C can be replaced by a thin film which have resistance R_L. Therefore the total resistance in a circuit consisted of R_0 and R_L is:

$$R = R_0 + R_L \tag{6}$$

where R_0 = load resistance outside the film and R_L = resistance of the film. Film resistance arise from imperfect of crystal structure of the atoms in the film, vibration of atoms in the film by temperature effect, and the presence of impurity in the film. On magnetic film the resistance is still added by interaction between conduction electrons originated from electrical current with the valence electrons in magnetic materials if the spin-spin opposites

3. Determination of capacitance of film

From eq. (1) we can fit the time and voltage data (t_i, v_i) according to the eq.:

$$y = y_0 + Ae^{-Bx} \tag{7}$$

where x is time and y is voltage. From the fitting we obtained fitting constants A and B where $B = 1/RC$. By inserting the value of R according to eq. (6) to constant B it will be determined the value of C:

$$C = \frac{1}{B(R_0 + R_L)} \tag{8}$$

Another way to determine the value C is finding the time constant τ corresponds to 0.66 $V_{\max}$, as stated in eq. (2). If τ and R known then:

$$C = \tau / R \tag{9}$$

Experimental Procedures

1. Materials research
   The material studied is thin permalloy film resulted from sputtering technique in the various deposition field from 50 s / d 600 G.
2. Research tools
   Principal equipment used in this study consisted of: AFG for AC voltage source. Frequency used in this experiment is 100 up to 1000 kHz, optical microscope 40 times magnification for making photograph of surface film and the images can be stored in a file. The oscilloscope is used for observe AFG input and output film waveforms. To observe the input voltage, output voltage and resistance of film it is used Digital Multimaster 570 brands Extech Instruments True RMS. In addition for photographing the output signal of oscilloscope it is used E4300 digital camera brand

Nixon, Nixon Corp production Japan, two point probes is used to supply voltages in the film, the potentiometer is used for determining the *R* that suitable to the requirements after serially arranged together with film. In addition to these tools it is also used Igor software for data fitting process between V_o and *t* according to equation (7).

Research procedures

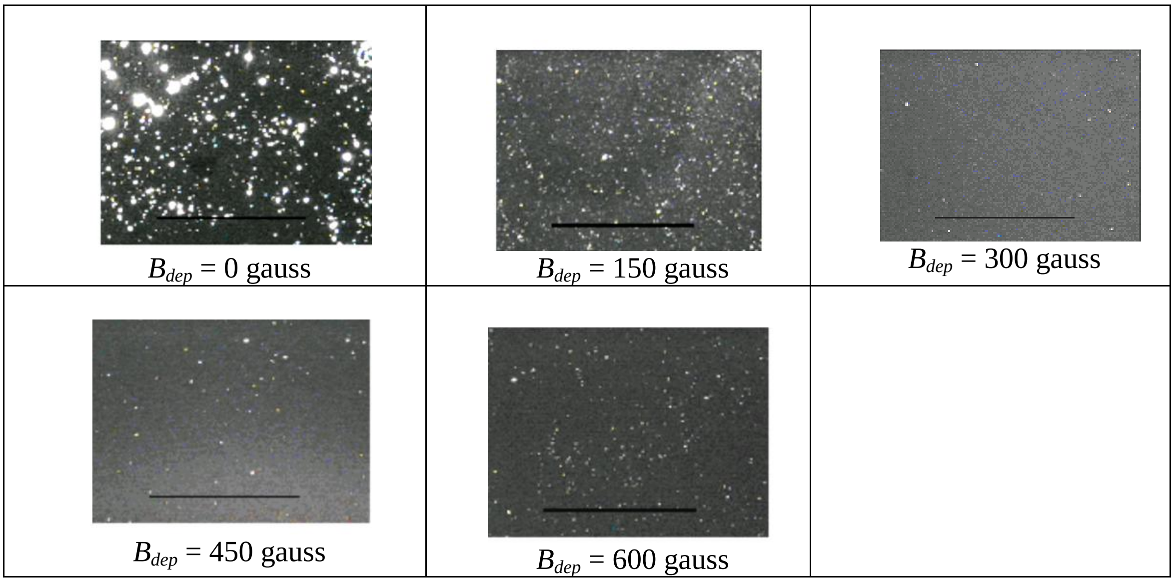
The research was conducted through the following procedures:

a. Thin surface film $Ni_{80}Fe_{20}$ is photographed with an optical microscope and stored with the specified file name.
b. Making a serial RC circuit as shown on Fig. 2 with installing a film as a capacitor and connecting device with the source of AFG AC voltage at a frequency 100 kHz. Observation of input and output voltages on oscilloscope is installed on dual mode (XY) so that V_i and V_o can be clearly distinguished. Furthermore, the display on the CRO screen is photographed with a digital camera. Meanwhile, measurements of film resistance is done with multimaster.
c. Repeating the procedure a and b for another sample.

Results and Discussion

3. Photopraph of $Ni_{80}Fe_{20}$ thin film

In Fig. 3 it is shown a photograph of $Ni_{80}Fe_{20}$ thin film resulting from deposition by sputtering technique in the various deposition field from 0 up to 600 gauss. The photograph was taken with an optical microscope. Black line at the bottom of the picture show the length of 1 mm. From these images it is appears that all the films containing porosities. Furthermore, it is known that the larger the deposition field the more number of porosities.



B_{dep} = 0 gauss

B_{dep} = 150 gauss

B_{dep} = 300 gauss

B_{dep} = 450 gauss

B_{dep} = 600 gauss

Fig. 3. Photograph of surface $Ni_{80}Fe_{20}$ thin film resulting from the sputtering at the various deposition field.

The larger deposition field from 0 up to 300 gauss the fewer and smaller average size of porosity. Therefore the surface of film is increasingly smooth. While in the deposition field of 300 up to 600 gauss surface film is seen increasingly rough. From the two conditions we know that the optimum B_{dep} to produce the smoothest surface film is 300 gauss. It is also estimated that value of *C* for this film is small compared to the other film.

2. Capacitive character of film

In Fig. 4 it is displayed photograph of *V* vs. *t* curve of each film on the oscilloscope screen. Picture is taken at a frequency 100 KHz. From the graph it can be seen that all the films reveal capacitive character. It is characterized by a change of signal from square wave in input to triangle wave in output. Output waveforms such as those indicating the charging and discharging that occurs in the film.

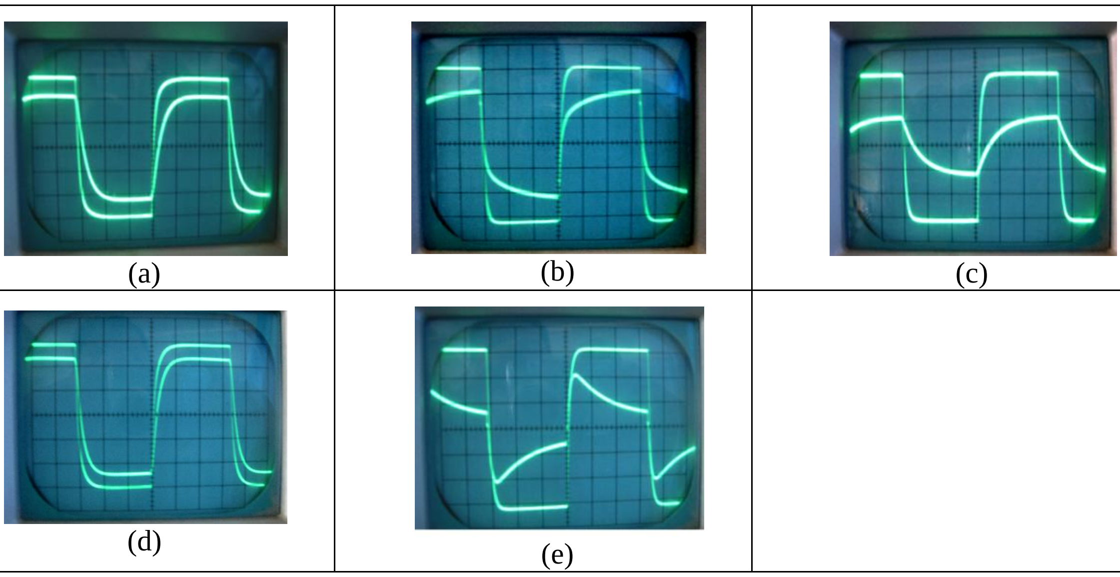

(a) (b) (c) (d) (e)

Fig. 4. Input and output signals for several films resulted from sputtering on various deposition field (a) 0 G, (b) 150 G, (c) 300 G, (d) 450 G, (e) 600 G.

Furthermore, by looking the changes in curvature level of V_o and value V_{mak} on each graph, it is appear that the magnitude of field affect the value of *C*. On the slowing curve, it is known that if 1/*RC* is large or C is small. In contrast on the steep curve V_o the value of *C* is large. In order to quantitatively determine the value of *C*, on subsection 3 it is displayed the values resulting from data fitting *V* vs. *t* of each sample.

3. Capacitance of film

in Table 1 it is shown equation of curve obtained from data fitting V_i vs t_i for each sample according to eq. (7). From the value *B* of each equation, by taking *R* as shown on column 4 of Table 1, it is obtained value of C as shown in columns 5 and 6.

Table 1 Equation from fitting of set data (ti, vi) for film resulted by sputtering on variation B_{dep}

B_{dep} (G)	*Fitting Equation*	*R* (Ω)	*C* from fitting constant of *B* (pF)	*C'* from time constant τ (pF)	Relative error $\frac{\Delta C'}{C'}\times 100\%$
0	$V(t) = 4{,}56 - 5{,}078e^{-4718800t}$	4654,6	45,53	60,91	25,25
150	$V(t) = 0{,}82 - 0{,}83e^{-4821800t}$	146139,6	1,42	1,48	4,16
300	$V(t) = 4{,}50 - 4{,}50e^{-1333200t}$	7938770	0,09	0,10	8,19
450	$V(t) = 9{,}25 - 10{,}87e^{-3343000t}$	177829,6	1,78	2,49	32,47
600	$V(t) = 7{,}4 - 8{,}06e^{-4{,}42740t}$	1078,6	2093,99	2614,40	19,91

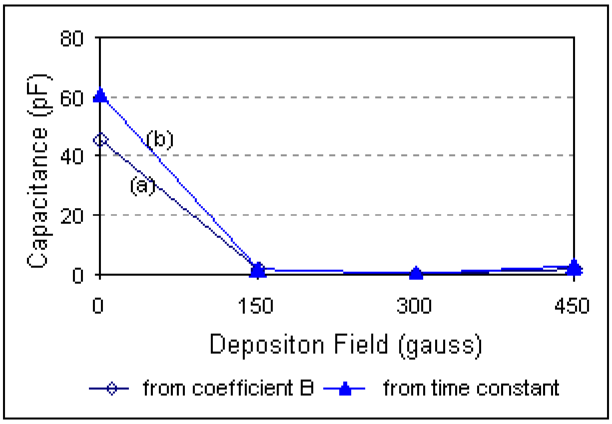


Fig. 5 Graph the relationship between capacitance and field deposition. (a) The value of C calculated from fitting constant B, (b) The value of C calculated from the time constant.

In column 5, table 1, it is appear that the capacitance of each film is small enough that is in order of 10^{-1} up to 10^{3} pF. Graphs depicting the relationship between capacitance and deposition field can be seen in Fig. 5. It is appear that the magnitude of the deposition field affect on the value of *C*. On deposition field of 0 up to 300 G, the value of C is dropped from 45.53 pF to 0.09 pF. In the deposition field of 300 up to 450 G, the value of C is rose from 0.09 pF up to 2093.99 pF. This is shows that the field B_{dep} 300 G is optimum field to produce the smoothest film and most little contains porosity relative to the other film. These results are consistent with that obtained by the photographs as refered in C.1.

Conclusion

From the discussion above it can be concluded some of the following: The method can be used as an alternative to obtain the smoothness of metal thin film. Permalloy thin film resulted on B_{dep} = 300 G has the smallest capacitance compared to the other permallois that is 0.09 pF which, so the film is smoother than others.

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