國外短期進修心得報告

單位：國防大學理工學院應用化學及材料科學系

報告人級職：中校副教授

姓名：黃其清

進修國家：美國

進修期間：95.07.25.至 95.12.31

報告日期：96.01.30

職深獲國家栽培，奉准赴美短期進修半年（命令請見附件一），進入德州農工大學化學工程學系郭育教授（Dow Professor/Dr. Yue Kuo）主持之 Thin Film Nano & Microelectronics Research Laboratory 研究、學習。

郭育教授，為薄膜電晶體（Thin Film Transistors，TFTs）專家，著作等身，擁有多項尊榮的學術頭銜（請參見其個人網頁 http://yuekuo.tamu.edu）。職有幸全程修習其開授之“Microelectronics Process Engineering”課程（該課程之大綱、第一次上課時學生需簽訂之「榮譽信條（Honor Code）」、以及最後一節課發予學生填寫之「教師評鑑表」等請參見附件二），且每週排定固定時間與郭育教授進行一對一討論，並參加其研究群之學術研討；在郭教授嚴格要求下，自覺受益甚多。茲擇要點簡述如下：

（一）藉修習其開授之課程，職除了瞭解「元件物理」及「VLSI 製造技術」外，對化學工程學理—「質量傳送」、「反應動力學」在「薄膜製程」之應用有更深刻的認識，對職提昇學能與精進教學亟有幫助。

（二）職與郭教授、國內核能研究所學術合作，進行「提昇薄膜電晶體（Thin Film Transistors，TFTs）對電磁脈衝（ElectroMagnetic Pulse，EMP）與高能輻射防護能力」之研究。並已有初步具體成果（會議論文之 Short Abstract 投稿證明、該研究之構想、以及職在美

期間對此研究所做簡報之投影片請參見附件三)。目前亦持續進行三邊研究合作，相信可提供國軍 C^4ISR 電子儀器裝備抗輻射能力之參考。

（三）在美短期進修期間，職之研究生成功合成出「四腳氧化鋅晶鬚（tetrapod ZnO whisker，t-ZnOw）」。據文獻報導，此物質製作之變阻器（Varistor）性能較優，可提供更佳之電磁脈衝防護能力[1]；且此物有微波吸收特性[2]，甚至可吸收紅外線[3]，在軍事上可用做反偵測材料，相當值得研究發展，亦契合職短期進修之目的。職曾與郭教授多次討論，借助其學識與經驗，設計「低壓三區加熱裝置反應器（Low Pressure 3-Zone Heating Element Reactor）」，以期獲得型態尺寸均勻、且結晶度佳、且高產量之 t-ZnOw 產物。該研究構想業已申請 96 年度國科會專題研究計畫（計畫書封面、該計畫英文摘要、反應器設計圖、及儀器設備費需求表等請見附件四)。

另外，職有一不成熟之想法，建請　鈞長卓參。德州農工大學內有軍校生部隊（Cadet Troop)，事實上，其在 1876 年創立之初即是軍校起家；如今，該校在工程領域排行全美第 14 名（2005 年 US News & World Report)，在政治、經濟方面則有布希學院（George Bush School）的加持而聲譽日隆，其發展歷程值得吾人深思。但另一重點是—前校長 Robert M. Gates 於 2006 年底新任美國國防部長；因此，

是否可能在「華美軍事合作」相關會議（談）上能協商以軍售訓練經費及作法送訓國軍人員赴德州農工大學攻讀學位或短期進修，以解決目前及以後可能面臨的准予出國進修員額縮減的問題。

參考文獻

[1] Wu Jun, Xie Changsheng, Bai Zikui, Zhu Bailin, Huang Kaijin, Wu Run, "Preparation of ZnO-glass varistor from tetrapod ZnO nanopowders," *Materials Science and Engineering B*59 (2002) pp. 157-161.

[2] Zuowan Zhou, Longsheng Chu, Shuchun Hu, "Microwave absorption behaviors of tetra-needle-like ZnO whiskers," *Materials Science and Engineering B*126 (2006) pp. 93-96.

[3] Run Wu, Changsheng Xie, "Formation of tetrapod ZnO nanowhiskers and its optical properties," *Materials Research Bulletin* 39 (2004) pp. 637-645.

國防大學　　令

機關地址：桃園龍潭郵政 90040 號信箱
傳真：(03)4890543
承辦人及電話：任敏強 03-3801126#316659

受文者：黃其清中校

發文日期：中華民國 95 年 5 月 4 日
發文字號：集暉字第 0950002224 號
速別：
密等及解密條件或保存期限：
附件：簡歷冊，紙本，1，頁。

主旨：核定貴學院所屬黃其清中校乙員赴美國德州農工大學化學工程學系短期進修半年，請照辦！

說明：

一、依據貴學院95年4月20日集錠字第0950000884號文辦理。

二、黃員以「94年度國外短期進修員額」赴美國德州農工大學化學工程學系短期進修，期限自95年6月30日起至95年12月31日止。

正本：國防大學中正理工學院、國防大學中正理工學院黃其清中校、國防大學總務處人事科

副本：內政部警政署入出境管理局（台北市廣州街 15 號）、國防部政治作戰局、國防部主計局、外交部駐美代表處（駐休仕頓台北經濟文化辦事處 11 Greenway Plaza, Suite 2006 Huston, TX. 77046, U.S.A.）、國防部人力司人事管理處、國防部人力司人力培育處、國軍綜合財務處（均含附件，請查照並登記資料）

校長陸軍二級上將　曾　金　陵

本件保存　　年　　　　縮影：　　　　檔號：

附件一（第二頁）

國防大學出國進修人員簡歷冊　表1

單位及單位編制號	中正理工學院（單位代碼 06G00）
身分證字號	E121256098
軍種官科	陸軍化學
級職	中校副教授
姓名	黃其清
英文姓名	Chyi-Ching Hwang
出生年月日	56年9月17日
出生地	高雄市
學歷	中正理工學院79年班應用化學系學士 成功大學化學工程博士
經歷	連長、助理教授、副教授
任官日期	79年7月2日
進修院校及科系	德州農工大學化工系 （Department of Chemical Engineering, Texas A&M University）
進修期限	半年
開學日期	95年7月1日
畢業日期	95年12月27日
預定出（返）國日期	95年06月30日出國；95年12月29日返國
上次進修回國日期	無出國紀錄
本階最大年限退伍日	103年7月1日
返國後延役預定退伍日	96年12月29日
返國後預派單位及職務	國防大學中正理工學院應用化學系中校副教授
出國期間列管報到單位	國防大學中正理工學院
在台通信地址（中文）	33509桃園縣大溪鎮瑞源里24鄰慈安六村58之1號
國外通信地址（英文）	Thin Film Nano & Microelectronics Research Lab, 235 J. E. Brown Engineering Building, MS 3122, Texas A&M University, College Station, TX77845-3122, U.S.A.

CHEN 475 Microelectronics Process Engineering

Description: This course is for senior level undergraduate and graduate students who would like to learn microelectronics, especially VLSI, fabrication processes. It includes fundamental unit processes, thin film materials, and device operation principles for semiconductor transistors and capacitors.

Instructor: Professor Yue Kuo, 235 J. E. Brown Engineering Building,
Tel. 845-9807, Email: yuekuo@tamu.edu http://yuekuo.tamu.edu

Office Hours: Monday and Wednesday 4:00-5:30 pm, other time by appointment.

Prerequisites: Physical Chemistry, Thermodynamics, Transport Phenomena, or Instructor's permission

Schedule: Monday, Wednesday, Friday 11:30 am - 12:20 pm, Zachry Room 119B

Textbook: VLSI Fabrication Principles, S. G. Ghandhi, 2nd Ed., John Wiley & Sons, 1994.

References: ULSI Technology, C. Chang and S. Sze, McGraw-Hill, 1996.
Amorphous and Poly Silicon Thin Film Transistors, Y. Kuo, Kluwer, 2004.

Midterm Exam	**30%**
Final Exam	**30%**
Report	**30%**
Homework, attendance, etc.	**10%**

Course Outline
1. Microelectronics technology and Industry over view
2. Semiconductor Material Properties
3. Solid State Transistor Operation Principles and IC Structures
4. Single Crystal Growth
5. Thin Film Depositions
   - Epitaxy
   - Oxidation
   - Chemical Vapor Deposition
   - Physical Vapor Deposition
   - Others
6. Doping
   - Diffusion
   - Ion Implantation
7. Etching and Contamination Cleaning
   - Wet and Dry
   - Contamination Cleaning
8. Lithography
   - Photoresist Materials and Processes
   - Pattern Transfer
9. Packaging
10. Process Integration (to make a complete IC)

Term Paper of CHEN 475 10/31/2006
Microelectronics Process Engineering
Instructor: Dr. Yue Kuo yuekuo@tamu.edu

Report Form: 10 pages in **MS Word format**
single space
total pages of figures < 2 pages, ≥ 3 figures per page
references (max. 1 page)

Criteria for grading: grading standard

1. Content (complete literature search, reviews) 30%
2. Organization (disciplines, rules, differentiation of items …) 30%
3. Analysis (data, theories, problems, advantages, disadvantages…) 30%
4. Summary 10%

Due date: **Dec. 1, 2006, 5:00pm**
submitted by internet attachment to yuekuo@tamu.edu

Topics of choice: **Choose only one specific topic or a portion of the topic**

1. Materials: High dielectric constant (high-k) materials (with equivalent oxide thickness less than 5 nm)
2. Epitaxy: epitaxy growth of Germanium on silicon wafer
3. Oxidation: oxidation of polycrystalline silicon (mechanism, processes, …)
4. Diffusion: diffusion of P, B, etc. in the high-k materials (mechanism, rate, comparison with diffusion in other materials, …)
5. Ion Implantation: shallow junction ion implantation (for example, < 10 nm)
6. CVD: deposition of high-k films by atomic layer deposition (ALD)
7. Etching: plasma etching of metal nitride or metal oxide films (such as, tantalum nitride, titanium nitride, aluminum oxide, tantalum oxide, etc.) …
8. Sputtering: reactive sputtering of metal oxides (e.g., hafnium oxide, tantalum oxide, aluminum oxide, etc.)
9. Lithography: immersion lithography (principles, new photoresist, etc.)
10. Other topics upon the approval of the instructor (OLED, transistors on flexible substrates, etc.)

Americans with Disabilities Act (ADA) Policy Statement

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of Student Life, Services for Students with Disabilities, in Room 126 of the Koldus Building or call 845-1637.

Academic Integrity Statement

"An Aggie does not lie, cheat, or steal or tolerate those who do."

Aggie Honor Code and the Honor Council Rules and Procedures on the web
http://www.tamu.edu/aggiehonor

It is further recommended that instructors print the following on assignments and examinations:

"On my honor, as an Aggie, I have neither given nor received unauthorized aid on this academic work."

____________________________ ____________________

Signature of student Date

附件二（第四頁）

TEXAS A&M UNIVERSITY MEASUREMENT AND RESEARCH SERVICES

INSTRUCTOR AND COURSE APPRAISAL

PLEASE RESPOND TO ANY ITEMS IN THIS SECTION BY MARKING THE APPROPRIATE SPACES. USE NO. 2 PENCIL ONLY. ERASE CHANGES OR CORRECTIONS COMPLETELY.

KUO YUE
CHEN475 500

YOUR RESPONSES WILL BE USED ONLY IF YOUR STUDENT ID SHOWS THAT YOU ARE APPROPRIATELY REGISTERED FOR THIS COURSE. YOUR ID WILL NOT BE AVAILABLE TO DEPARTMENTAL PERSONNEL UNDER NORMAL SITUATIONS.

FOR INSTRUCTOR USE ONLY
10/31/06

CLASS ENROLLMENT	DEPT. CODE	COURSE CODE	SECTION CODE
1 0 4	0 9	4 7 5	5 0 0

STUDENT ID:

EXPECTED GRADE IN COURSE: A B C D F

NUMBER OF TIMES ATTEMPTED TO SEE INSTRUCTOR OUTSIDE OF THE CLASSROOM: 0, 1-3, 4-7, 8+

HOURS I WORKED ON THIS COURSE PER WEEK: 1-3, 4-5, 6-10, 11-15, 16+

NUMBER OF TIMES SAW INSTRUCTOR OUTSIDE OF THE CLASSROOM: 0, 1-3, 4-7, 8+

HOW MANY DAYS OF CLASS I MISSED: 0, 1-2, 3-5, 6-10, 11+

Please Read Each Statement Carefully. Your Responses Will Be Used To Rank Your Instructor Among Other Faculty Members. Your Instructor Will Not Receive These Forms. A Summary Of The Data From The Forms For The Class Will Be Presented During The Instructors Evaluation.

CHOOSE THE LETTER WHICH REFLECTS YOUR FEELING FOR EACH STATEMENT
'A' DESERVES AN AWARD IN THIS AREA, EXCELLENT
'B' VERY GOOD
'C' GOOD
'D' DOES NOT PERFORM WELL IN THIS AREA
'E' HAS SERIOUS DEFICIENCIES IN THE AREA WHICH ARE DETRIMENTAL TO STUDENTS

SAMPLE RESPONSE

LEC

1	Class Preparation: The class activities are well-prepared and organized	A B C D E
2	Assignments: The examinations, assignments, projects, etc. aid me in achieving the class objectives.	A B C D E
3	Communications: The instructor clearly explains material so that I can understand it.	A B C D E
4	Responsiveness: The instructor is open to my questions, and effectively answers them.	A B C D E
5	Academic concern: The instructor seems to care that I learn this material.	A B C D E
6	Availability: The instructor willingly makes time to help other students and me.	A B C D E
7	Fairness in Grading: The instructor is fair and consistent in evaluating my performance in the course.	A B C D E
8	Environment: The instructor maintains a good learning environment for me.	A B C D E
9		A B C D E
10		A B C D E
11		A B C D E
12		A B C D E
13		A B C D E
14		A B C D E

Do you believe your response to each question above reflects the opinion of most of the students in the class? Yes No Don't Know

If your answer is no please indicate which questions you believe differed for you from most of the other students, and why you believe this difference occurred. 1 2 3 4 5 6 7 8 9 10 11 12 13 14

* * PLEASE WRITE COMMENTS ON REVERSE SIDE OF THIS FORM * *

Mark Reflex® by NCS MM219738v1-1 131211 ED06 Printed in U.S.A.

State law requires that you be informed of the following: (1) you are entitled to request to be informed about the information about yourself collected by the use of this form (with a few exceptions as provided by law); (2) you are entitled to receive and review that information; and (3) you are entitled to have the information corrected at no charge to you.

Comments for LEC

What are the most positive aspects of this course?

Grading has been fair and consistent. Circle Yes or No. If No, tell why.

What qualities did you like most about your instructor?

What qualities did you like least about your instructor?

Additional comments about the course and the instructor.

Effects of gamma ray irradiation on the electric characters of thin film transistor (TFT) devices

Abstract

In this project, the electric characters' stabilities of gamma ray irradiated TFT devices and their composing materials will be evaluated under various dosages and dose rates of gamma ray irradiation. Both staggered and inverted, staggered types of hydrogenated amorphous silicon (i.e., a-Si:H) TFTs, as well as the composing materials acting as substrates (i.e., glass or plastic), electrodes (such as aluminum, chromium, nickel, and molybdenum), gate dielectrics (for example, silica, silicon nitride, and tantalum oxide), and a-Si:H will be used for testing, respectively. Gamma ray irradiations will be performed at room temperature with the total dose and dosage rate up to 25 Mrad and 50 Krad/min by using Cobalt-60 as the radiation source. Comparing the electric characters (i.e., mobility, on-current, off-current, leakage current, threshold voltage, and subthreshold slope) of the pre-irradiation TFT devices with those of post -irradiation ones, it is considered that these results may have implications in hardness assurance testing. On the other hand, the composing materials will be examined with electron spin resonance (ESR) after irradiation. In addition, the dependences of annealing conditions and aged time on the recovery property of radiation-damaged samples will also be explored. Judging from these experimental results, coupling with the microscopic analysis, a possible failure mechanism of TFT devices suffered from the gamma ray irradiation may be proposed.

1. Introduction

Thin film transistor (TFT), a promising electric device with rapidly increasing usages in numerous fields, has provided itself for applications including displays, imagers, pixel or circuit drivers, and a wide rage of biological, chemical, gases, magnetic, photonic, ionic, and electronic sensors. Therefore, TFTs are rather important for obtaining information and for the purposes of commanding, controlling, communicating, and detecting.

Many scenarios exist that can require TFT devices to operate during or after irradiation because they may be exposed to irradiation for a period of time in aerospace plane and satellite systems, nuclear powder plant systems or weapon systems.

It is known that, generally, the solid-state devices irradiated with high-energy radiations may lead to the following three events:

1) Formation of electron-hole pairs
   They result from the photoelectric effect and can generate the leakage current and cause the leakage passageway;
2) Inverting spin orientation of electrons
   They situate an exciting state and thus against the Hund rule;
3) Thermal effect.
   The device's temperature is raised by the released energy due to the recombination of electron-hole pairs. The device may be damaged by thermal shock, or a phenomenon of thermal diffusion. These may occur on the interfaces of thin films so as to change the compositions and the properties.

These events may cause the permanent damage or recoverable failure to the electric devices.

Although considerable efforts have been performed to investigate the influences of irradiation on the response of other solid-state devices such as MOSs and SOIs, there is no literature reporting the irradiation effects on TFT response. Also, the relevant testing standards and the requirements of military specifications with respect to the TFTs' irradiated-hardness have not been established yet. It is thus worth researching this subject, which may provide useful data to estimate the radiation hardness of TFTs. Besides, it is also important to obtain an understanding of the effects of irradiation intensity on the TFTs' composing materials acting as substrates (i.e., glass or plastic), electrodes (such as aluminum, chromium, nickel, and molybdenum), gate dielectrics (for example, silica, silicon nitride, and tantalum oxide), and a-Si:H so as to assist in improving the radiation-proofing performances of TFTs.

2. Research scheme

Although TFTs have been widely used in various areas and the applications are growing continuously, their structures can be divided into three categories: 1) staggered, 2) inverted, staggered, and 3) coplanar. Among them, the former two structures are commonly used in a-Si:H TFTs which possess unique fabrication characteristics: low-temperature, high-throughput, and large-area. Therefore, a-Si:H TFTs with the two structures are selected as the objects in this study.

In the real situation of irradiation, the radiation frequency certainly is continuous and distributes in a wide range. The gamma ray emitted from cobalt-60 is discrete with two characteristic peaks appearing on the electromagnetic frequency spectrum. Even though, cobalt-60 will be used as the radiation source because it is readily available (that is, cobalt-60 is convenient to obtain and easy to control).

The a-Si:H TFTs are manufactured by the Nano Thin Film & Microelectronics Research Laboratory. The basic unit processes include thin film deposition (using sputtering and PECVD techniques), photolithography, wet etching and plasma etching, annealing, and cleaning.

When batches of TFTs have been prepared, their electric properties should be measured prior to irradiation test.

The common requirements of a TFT are high field-effect mobility, high ratio of on current to off current, low threshold voltage, and low subthreshold slope. It is thought that the above items should be measured for the pre- and post-irradiated TFT samples; and thus their radiation hardness can be evaluated by comparing these characters values of pre- and post-irradiation.

When the design or the structure of the a-Si:H TFT is fixed, its performance is dependent on factors such as the properites of composing materials, the dimensions of thin films, and influences of other process steps (for example, the etch method, the substrate temperature, the power and frequency of PECVD, the temperature and time of heat treatment, and so on). Therefore, the composing materials will also be examined with irradiation in this study. Moreover, the properties of the a-Si:H channel and annealing conditions will be selected as the experimental parameters.

By understanding the correlation among the change of electric characteristics, effects of experimental parameters, and the testing results of the irradiated composing materials, it is expected that the radiation hardness of the a-Si:H TFT may be improved and a possible radiation-damaged mechanism may be proposed as well.

3. Experimental procedures

The TFT samples will be fabricated by means of the Thin Film Nano & Microelectronics Research Laboratories' PECVD process. (The whole unit steps and the specifications for TFTs should be described briefly.) In addition, the composing materials will also be prepared in a plate, bulk form for testing.

Gamma-ray irradiations will be performed under the delidded condition using Co-60 as the radiation source. The irradiation effects for the TFT samples and individual composing materials can be examined through the variations of the electric characteristics and the analysis of electron spin resonance (ESR), respectively. The irradiation conditions, both the total dosage and the dose rate, will be set in the ranges of 1-25 Mrad and 1-50 Krad/min, respectively. It should be noted that the dose rate and the total dosage can be adjusted by the exposed time and the distance between the irradiated objects and cobalt-60, respectively.

An HP 4140B DC parameter analyzer, inside a black box, is employed to measure the relevant electric characteristics (i.e., mobility, on-current, off-current, threshold voltage, subthreshold slope, etc.) of the pre- and post-irradiation TFT samples at room temperature in air.

The irradiated TFT samples with abnormal electric characters; will be aged (at 25 degrees centigrade, 65% relative humidity) or annealed (less than 400 degrees centigrade) for a period of time. Then, the electric characteristics of the aged TFT samples or annealed ones will be inspected again to investigate their recoverable properties.

To examine the potential influence of irradiation-induced heat on the damage /failure of TFTs, the thin films and thier interfaces of the irradiated TFT samples will be observed by TEM and analyzed with WDS.

4. Possible problems & Solving ways

It is not necessary to design a new TFT structure and to change the fabrication process; this proposal seems to be practical and inexpensive.

However,

1) there is a gap between my specialty and this research. I am lack of the knowledge about semiconductor physics and microelectronics.
2) These key items, such as preparation of the TFT samples, measurement the experimental data and expertise of the obtained results, have to rely on the Thin Film Nano & Microelectronics Research Laboratory.

5. Expected goals of this research

1) Offering the attained outcomes to the applications of national defense
2) Cultivating mutual cooperation
3) Expanding my academic field and enrich my research ability
4) At least one paper published on a famous journal

6. Further development

If everything goes well and the goals set can be accomplished, I'd like to...

1) test other types of TFTs and various potential composing materials
2) use synchronous radiation, Alpha particles, or protons as radiation sources
3) take the Taguchi method to analyze the relationship among experimental parameters, material properties, and electric characters so as to obtain the optimum radiation hardness of TFTs.

Effects of radiation on TFT devices

□ Why do we do this research?

1. *TFTs are important for obtaining information and for the purposes commanding, controlling, communicating, and detecting.*

2. *It is required that TFTs can operate during or after irradiation* (such as aerosapce plane and satellite systems, nuclear power plant systems, or weapon systems, etc.).

3. *There is no literature reporting the irradiation effect of irradiation on TFTs. The testing standard and required specifications have not been established.*

A scheme for my further research

Effect of gamma ray irradiation on the electric characters of thin film transistor (TFT) devices

Chyi-Ching Hwang
Sept. 22, 2006
TAMU

Department of Applied Chemistry, Chung Cheng Institute of Technology, National Defense University

Purposes of this research

- ☐ It may provide useful data to estimate the radiation hardness of TFTs.
- ☐ To get an understanding of the radiation effects on TFT's composing materials so as to assist in improving TFT's radiation-proofing performances.

So, it is worth doing this research, right?

Events result from high-energy radiation

- ☐ Formation of electron-hole pairs

  leakage current & leakage passageway

- ☐ Inverting spin orientation of electrons

  againsting the Hund rule

- ☐ Heat effect

  thermal shock & thermal diffusion

Selections of research objects (1/3)

- ☐ The a-Si:H TFTs possess unique fabrication characteristics:
  1. low-temperature
  2. high-throughput
  3. large-area.

Therefore, a-Si:H TFTs with the 1) staggered and 2) inverted, staggered structures are selected as objects.

Selections of research objects (2/3)

- In the real situation of irradiation, the radiation frequency certainly is continuous and distributes in a wide range.
- The r-ray emitted from ^{60}Co is discrete with two characteristic peaks appearing on the electromagnetic-frequency spectrum.
- Use of the r-ray emitted from ^{60}Co is readily available because it is :

  1. convenient to be obtained
  2. easy to be controlled

Therefore, ^{60}Co will be selected as the radiation source.

Measurements of electric characteristics for TFTs

- Common requirements of TFTs:
  1. high field-effect mobility
  2. high I_{on}/I_{off}
  3. low threshold voltage
  4. low subthreshold slope

- These items are measured by using the HP 4140B DC parameter analyzer.

The radiation hardness can be evaluated by comparing these characteristic values of pre- and post-irradiated TFT samples.

Department of Applied Chemistry, Chung Cheng Institute of Technology, National Defense University

Selections of research objects (3/3)

- Factors affecting TFTs' performances (fixed design & process steps)
  1. properties of composing materials
  2. dimensions of thin films
  3. Process parameters

Composing materials will also be irradiated to examine their irradiation stabilities analyzed by ESR.

Self-evaluation (1/2)

- Advantages:
  1. It is not necessary to design a new TFT structure and to change fabrication process.
  2. This project seems to be practical and inexpensive.

Let's give it a try!

Self-evalution (2/2)

- Possible problems & Solving ways
  1. A gap between my specialty and this research.
  2. Without key techniques and instruments.

Just study hard and keep touch with you closely!

Expected goals of this research

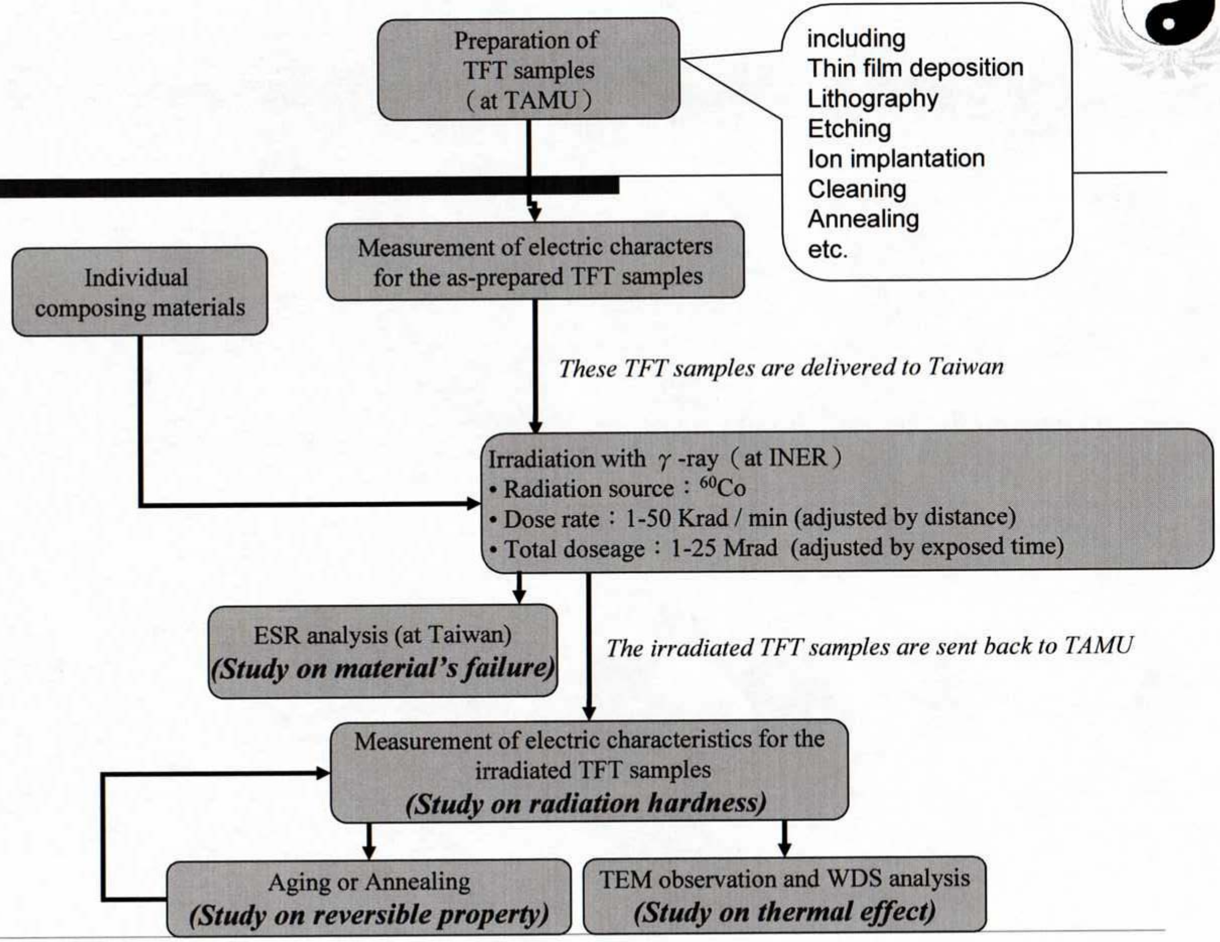
- Offering the attained outcomes to the applications of national defense
- Cultivating mutual cooperation
- Expanding my academic field and enriching my research ability
- At least one paper published on a famous journal

Further Developments

If everything goes well and the goals set can be accomplished, I'd like to…

- ☐ test other types of TFTs and a variety of potential composing materials
- ☐ use synchronous radiation, α particles, or protons as radiation sources
- ☐ take the Taguchi method to analyze the relationship among experimental parameters, material properties, and electric characteristics so as to obtain the optimum radiation hardness of TFTs.

Experimental Procedures



Department of Applied Chemistry Chung Cheng Institute of Technology National Defense University

Thank you for listening

Department of Applied Chemistry Chung Cheng Institute of Technology National Defense University

附件五（第一頁）

行政院國家科學委員會專題研究計畫申請書

一、基本資料：　　　　申請條碼：95WFE0900007

本申請案所需經費(單選)	A類(研究主持費及執行計畫所須經費)				
計畫類別（單選）	一般型研究計畫				
研究型別	個別型計畫				
計畫歸屬	工程處				
申請機構/系所（單位）	國防大學應用化學及材料科學學系				
本計畫主持人姓名	黃其清	職稱	副教授	身分證號碼	*******098
本計畫名稱 中文	燃燒法合成多腳氧化鋅晶鬚---反應器研製,產物性質檢測,及前導性應用研究				
本計畫名稱 英文	Studies on combustion synthesis of multipod ZnO whiskers---reactor design, product characterizations, and preliminary studies on potential applications				
整合型總計畫名稱					
整合型總計畫主持人				身分證號碼	
全程執行期限	自民國 96 年 08 月 01 日起至民國 98 年 07 月 31 日				
研究學門(請參考本申請書所附之學門專長分類表填寫)	學門代碼	名稱(如為其他類，請自行填寫學門)			
	E0209	材料在化工之應用			
研究性質	導向性基礎研究				
本年度申請主持國科會各類研究計畫(含預核案)共 1 件。(共同主持之計畫不予計入) 本件在本年度所申請之計畫中優先順序(不得重複)為第 1 。					
本計畫是否為國際合作計畫：否					
本計畫是否申請海洋研究船：否					
本計畫是否有進行下列實驗：(勾選下列任一項，須附相關實驗之同意文件)					
計畫連絡人	姓名： 黃其清 電話：(公) (03)3891716 ext.312 (宅/手機) 0912539206				
通訊地址	桃園縣大溪鎮三元一街 190 號國防大學中正理工學院應用化學及材料科學學系				
傳真號碼	(03)3892494	E-MAIL：	cchwang1@ccit.edu.tw		

申請人簽章：　　　　單位系所主管簽章：　　　　執行機關簽章：

十一、研究計畫中英文摘要：請就本計畫要點作一概述，並依本計畫性質自訂關鍵詞。

（一）計畫中文摘要。（五百字以內）

（二）計畫英文摘要。（五百字以內）

ABSTRACT

Among all kinds of whiskers, ZnO whiskers are the only one with the multipod shape (i.e., m-ZnOw). They possess many good properties, such as semiconductivity, photoelectric characters, wear resistant, vibration insulation, and microwave absorption. They can be widely applied as both functional and structural materials because of their peculiar shape and single crystalline character. They are also less expensive to produce than other fibers or whiskers used mainly as reinforcement. In our recent study on the synthesis of ZnO powders with different types of morphologies, a combustion method has been developed by using zinc nitrate, metallic zinc and glycine as reactants. It is found that gas phase reaction seems to play an important role in the formation process of rod-like and tetrapod ZnO. The metallic Zn, after evaporation, reacts with O_2 or NO_x, generated by the decomposition of NO_3^- ions, to form ZnO. And its nucleation and subsequent growth lead to the formation of the rod-like and tetrapod structures. In this 2-year project, the multipod ZnO will be directly prepared quickly via a practical and economical oxidation/combustion approach, different form traditional thermal evaporation methods at high temperature and aqueous solution routes with slow production rate. A horizontal furnace with 3-zone heating element together with an appropriate design is utilized as the synthesizing instrument, whereas metallic Zn is used as the starting material. It is expected that the proposed mechanism during synthesis reaction, including evaporation of Zn, following oxidation/combustion, formation of ZnO nuclei, and growth of ZnO, can be controlled *via* the adjustments of Zn particle size, pressure of gas mixture (N_2+O_2) and oxygen fraction, temperature distribution, and the resident time in each zone. As a result, the yield, morphology (i.e., shape, size, and uniformity) and properties (such as specific surface area, PL character, etc.) of the product can be controlled. The goal of the first-year work is to

establish a technique to prepare m-ZnOw, that is, to set up the synthesizing instrument and to define the processing operation procedure. The objective of the second-year study is to examine the effects of relevant experimental parameters as mentioned above on the products? yield, morphology, and properties, which will be analyzed with chemical separation, XRD, SEM, TEM, AES, PL spectra, etc. Moreover, the related researches such as nhancement of m-ZnOw PL character by doping with In_2O_3 or GeO_2 using this technique? and ? Microwave-absorption behavior of m-ZnOw? will also be preliminarily performed.

Keywords: multipod ZnO whiskers; Combustion Synthesis; Reactor; Morphology; Characterizations

此時直接從氣相傳來的粒子，經與晶粒碰撞後相結合，形成晶粒的一部份而繼續成長。而推動晶粒繼續成長的驅動力（driving force），則來自晶粒尺寸增加所調降之整體自由能，△G。且須在其附著於任何界面或隨氣流逸散前即完成晶粒成長形成粉體顆粒而沉降。因此反應器的設計與操作，應儘可能讓有利於氣相成核/長晶（gas phase nucleation/growth）的條件發生。因此，反應氣體（鋅蒸氣與氧氣）及氣相產物在反應器內的濃度，應控制在飽和點之上，而此濃度之控制，則與鋅蒸氣濃度、氧氣分壓、操作溫度、管內流路設計有關。然而，必須注意避免氣相產物濃度及操作溫度太高，以致碰撞頻率過於激烈因而干擾正常的成核/成長過程，使產物的形態與尺寸不均勻；亦應避免原本個別且獨立的產物晶粒因成長所增加之尺寸，使其大至足以與附近其他晶粒接觸而聚結（coalescence），復因高溫晶粒間進行內擴散（inter-diffusion）而發生類似燒結（sintering）的現象。因此，管內產氣相產物濃度與溫度分佈對於成核/成長之控制，至為重要。

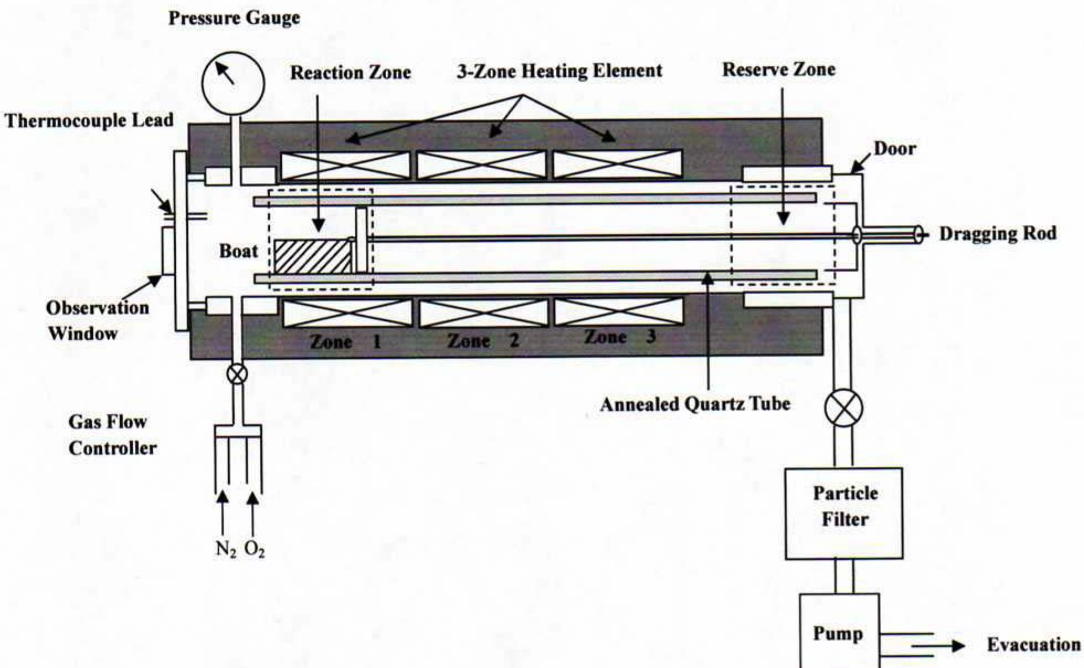


圖 9. 「低壓三區加熱裝置反應器（Low Pressure 3-Zone Heating Element Reactor）」示意圖

附件五（第五頁）

儀器及資訊設備	低壓三區加熱裝置反應器 /Low Pressure 3-Zone Heating Element Reactor	本計畫使用「低壓三區加熱裝置反應器」是一種水平爐管熱壁式的反應器。反應器本身是以經回火的石英管、一組「三區加熱裝置」、用以量測爐管溫度的熱電偶、以及抽氣系統的幫浦與管閥組件所構成。 所謂三區加熱裝置，即是一組用來加熱爐管之熱阻式加熱器，環繞於石英管外圍。此加熱器分成三個部分，對爐管的前、中、後等三個區域個別加溫，以調節爐管的溫度分佈。 氣體混合物〔N2+O2，其中 N2 做為吹淨與稀釋用途，O2 與鋅蒸氣反應生成 ZnO〕於爐管前方送入爐管內，反應物置於同樣已回火之石英載皿中，由爐門放進爐管內部，藉由位於爐管外圍的三區加熱裝置所提供之熱能，達到「鋅蒸發、氧化、成核、成長」所需之溫度，以進行多腳氧化鋅晶鬚 (multipod-ZnO whisker，m-ZnOw)合成反應。在設計上，此三區溫度可單獨控制以期獲得所欲之溫度梯度，最高溫度可達 1200 ℃，溫控誤差在±5 ℃間。石英爐管長 120 cm，每區加熱長度約為 25 cm，剩餘長度做為預備區，在三區加熱裝置到達設定溫度之預熱期間存放鋅粉及載皿之用；此長度為 45 cm，應足以遠離第三區，使鋅粉不受其溫度影響	1	450,000	450,000	450,000	無

合　　　　　　　　　計	450,000	450, 000	

第 2 年

類別	設備名稱（中文/英文）	說　明	數　量	單　價	金　額	經費來源	
						本會補助經費需求	提供配合款之機構名稱及金額
合				計			