The Development of LIGA Simulated Teaching Materials Based on Economic point

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Abstract

LIGA describes a fabrication technology used to create high-aspect-ratio microstructures. It is also an evolutionary technique of the mechanical industry, which extends the scale of construction to nanometers. Students of the mechanical and computer-aided engineering departments at the National Formosa University in Taiwan enroll in a MEMS course during their fourth year, in which course they learn systematic integration of LIGA knowledge.

This research develops a curriculum design, with simulation teaching aids for high-level technology instruction, which is the most economical method to allow students in technological universities or colleges to become acquainted with LIGA; and through personal contact with simulation equipment, facilitate integration into the semiconductor manufacturing industry upon graduation.

It is expected that the outcomes of this study will effectively improve the quality of teaching, by allowing most of students in technological universities or colleges to become acquainted with the semiconductor manufacturing industry through attending this course.

Keyword: technological university or college education, micro electromechanical system, LIGA,

curriculum design, simulation teaching aids, teaching experiment

I. Introduction

Micro-Electro-Mechanical Systems (MEMS) is an integration technology of optical, mechanical electrical, control, and chemical technologies. By employing this new technology, product miniaturization could increase added value and lower costs.

Due to the expensive nature of facilities in Taiwan, MEMS is only taught at colleges or graduate schools, while a very limited number of students in institutes of technology can be instructed to conduct experiments, leaving the majority of students without access to the production processes of MEMS.

This study aims to analyze Lithographic Gavanoforming Abforming (LIGA) in MEMS, and proposes suggestions for curriculum planning. Furthermore, this study designs and constructs teaching contents, devises experiments, and produces experimental tools to construct a set of teaching materials and instructional approaches for technical and vocational students.

II. Technology curriculum design and development of theories

The development of a technological curriculum includes defining the goals of the course, formulating a curriculum outline, determining the sequence of contents, and writing up teaching materials. To complete this work, curriculum designers must have a basic understanding of the contents, namely, knowledge, skills, and attitude in order to devise an appropriate technological curriculum.

During curriculum planning, various approaches could be utilized. Finch & Crunkilton (1989) suggested that the most common approach is introspection, which is to construct course content based on one’s perceptions. Furthermore, a systematic curriculum construction includes needs analysis, which is a process of systematic analysis directed at the content, and information obtained from needs analysis is the basic guideline for the curriculum. Information collection skills for needs analysis includes, document analysis, observations, interviews, surveys, and meetings.(McCormick, E. J1989; Steadham, S. V. 1980; Bemis, S. E., Belenky, A. H. & Soder, D. A 1983; Gael, S. 1983).

Guidelines of a technological education curriculum are presented as follows:

A. Needs-directed

The design of a technology curriculum should reflect the changes of a knowledge based economy, in order that courses could strengthen personal adaptability as well as enterprises’ competiveness.

B. System-directed

When designing a technology curriculum, designers should think circumspectly, execute steps strictly, and consider industrial applications.

C. Hierarchy-oriented learning

The content and sequence of a technology curriculum should stress continuity and coherence, and be arranged from simple to more complicated concepts.

D. Empirical evaluation

A technology curriculum should evaluate students based on the 3P concept, namely project, product, and performance, as well as learners' portfolio.

E. Execution-directed

The planning process of a technology curriculum is shown in Figure 1. The sequence of each step is reversible, and feedback is dynamic.

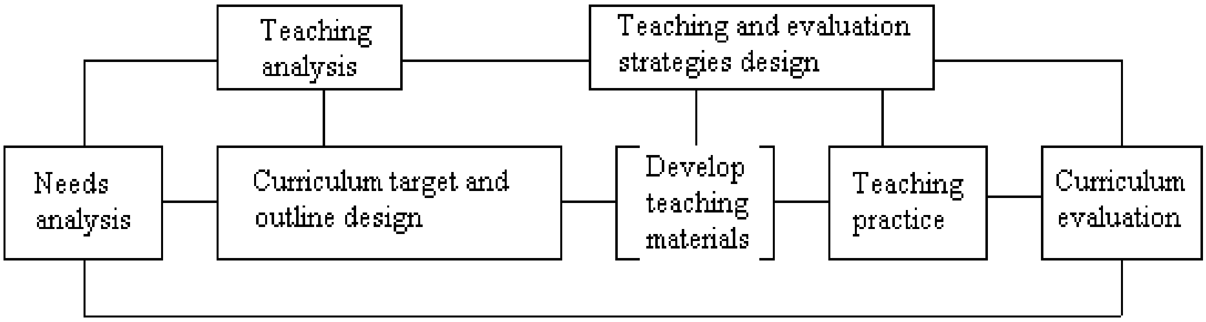

Figure 1 Technology curriculum planning process

III. Technical content of LIGA

This research adopts an introspective method that outlines the technical content of LIGA. The research framework is shown in Figure 2.

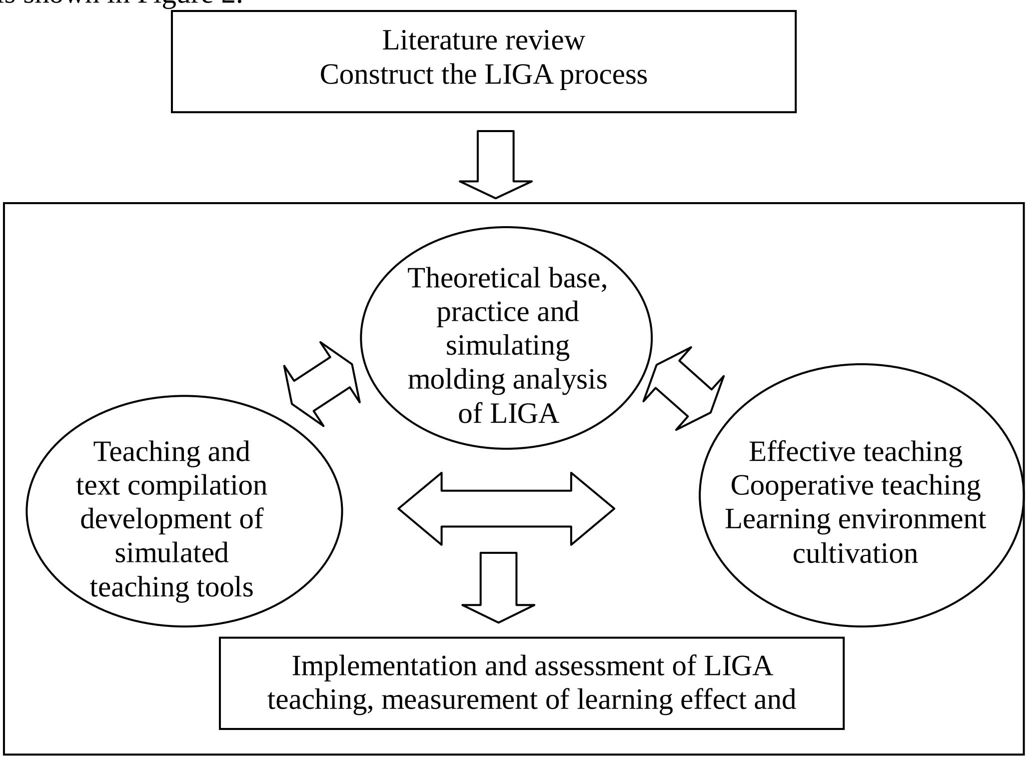

Figure 2 Research framework

The technical domain of LIGA consists of three aspects, namely;

- Lithography
- Micro Electroforming
- Micro Molding

LIGA uses a photochemical reaction to precisely magnify or minify the patterns on a photo mask, and print on the surface of a substrate coated with photoresist. After being developed, the photoresist pattern and photo may be identical or complementary, and then, the anti-corrosion feature of the photoresist is used to erode the substrate surface in order to obtain delicate and complex patterns. The procedures are shown in Figure 3:

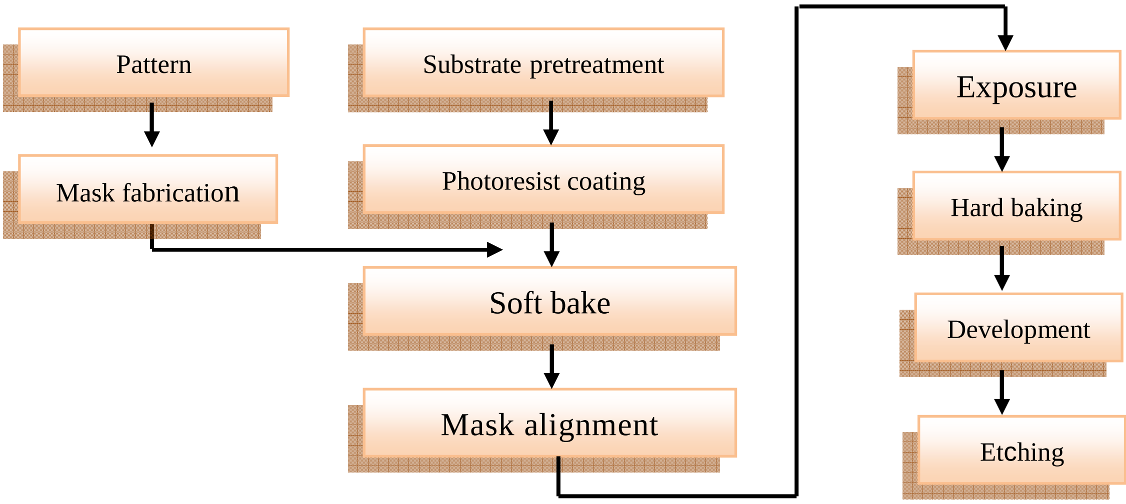

Figure 3 Flowchart of LIGA

IV. Content of teaching materials

The contents of teaching materials for LIGA are obtained through needs analysis, which are described as follows:

A. Pattern and mask fabrication

CAD is used to design a pattern, and image processing is used to minify the original file. Then, the pattern is further reduced using a camera to obtain a precise photoplate. The contact copy method is used to copy the pattern onto a high purity chrome-plated glass plate, coated with photoresist.

B. Photoresist coasting

Photoresist is a type of photosensitive macromolecular solution. To coat photoresist, the substrate is first fixed onto a spin coater, and photoresist is dripped onto the substrate until it spreads and evenly coats the substrate.

C. Soft baking

The purpose of soft baking is to heat the photoresist film in order that the solution vaporizes, which improves the adhesion of the photoresist. Soft baking is usually performed on a hot plate, at a temperature of approximately 90~100℃.

D. Mask alignment

The mask should be aligned before each exposure, as aligning the mask can ensure precise positioning, and marks used for positioning should be the same type.

E. Exposure

The photoresist is irradiated against light in order to generate a photochemical reaction. The process of changing the internal structure of photoresist material is called “exposure”, and Ultra-violet (UV) is often used to irradiate the photoresist for exposure.

F. Hard baking

The purpose of hard baking is to further harden the photoresist, which makes it difficult for the unexposed photoresist to dissolve.

G. Development

After exposure, the pattern of the photoresist material is developed in a chemical solution, which is a process called “development”. The chemical solution used for development is called “developer”.

H. Etching

After development, the oxide layer covered by the photoresist must be removed. The process of removing such an oxide layer is called “etching”.

I. Photoresist stripping

After etching, the photoresist material must be stripped off in a process called photoresist “stripping”, which is usually carried out in a chemical solution, such as acetone. An ionic jet can also be used to strip the photoresist, under vacuum conditions.

J. Electroforming

Electroforming refers to a process in which a layer of heavier metal is deposited from the surface of a workpiece onto the negative pole in an electrical field action. The basic devices include an electrolyzer, DC, blender, circulating filtering system, and heating and cooling devices.

V. Planning experimental items

According to technical assessment on, and analysis of LIGA, as listed in Table 1, the simulation experimental devices to be prepared includes, a photoresist spin coater, a photo exposure machine for instructional use, and an electrolyzer for instructional use.

Table 1: Technical assessment on and analysis of simulated molding of LIGA technology

Item No.	Molding procedures	Whether appropriate for use in simulation experiments	Methods
1	Mask fabrication	Yes	Physical objects are too expensive. Use film to replace mask.
2	Photoresist coating	Yes	Design and create a photoresist spin coaster
3	Soft baking	No	Use oven instead
4	Mask alignment	Yes	Design and create a photo exposure machine for instructional use
5	Exposure	Yes	Use lamp bulb to replace X-ray light source
6	Hard baking	No,	Use oven instead
7	Development	No,	Use plastic basin to replace developing tub.
8	Etching	No,	Use iron chloride as corrosive.
9	Photoresist stripping	No,	Use acetone as wash
10	Electroforming	Yes	Design and create a small electrolyzer for electroforming

VI. Teaching efficacy evaluation

This study employs an empirical evaluation to achieve practicality within a curriculum. The subjects are the junior students of the Department of Mechanical and Computer-aided Engineering, National Formosa University. Students are asked to complete a learning efficacy survey on the course of LIGA experiments. Results are used as reference for teaching material evaluations.

A. Survey results

Table 2 presents the results of the survey. A total of 40 questionnaires are distributed, and 24 effective samples are collected. The respondents are asked to read the statements for each item, and rate the item on a 5-point Likert scale, where 1 is strongly disagree; 2 is disagree; 3 is neural; 4 is agree; and 5 is strongly agree. Columns 2 to 6 of the table indicate the number of students giving the same score. The last column presents the results of average survey scores.

Table 2 Results of survey

Questions	1	2	3	4	5	Average
Q1. Is the course challenging and interesting?	0	0	1	9	14	4.54
Q2. Had you gained a considerable level of LIGA knowledge prior to the course?	1	1	13	6	3	3.38
Q3.Have you learned more than expected from this course?	0	0	3	10	11	4.33
Q4.Have you effectively learned LIGA knowledge?	0	0	2	9	13	4.46
Q5.Could you discuss LIGA techniques with confidence?	0	0	7	10	7	4
Q6. Could you read articles which talk about LIGA?	0	0	9	7	8	3.96
Q7. Do you think this course could be modified?	0	1	11	8	4	3.63
Q8. If modification is necessary, where should they be applied?	1. Refining course content 2. Introducing ways to improve technology 3. Improving process equipment					

B. Analysis of results

In order to understand students' feedback on course content, material design, and teaching methods, this study analyzes the survey results. In terms of course content, 96% of students reported that it is challenging and interesting (Question 1); whereas one student suggested that it makes no difference. Prior to this course, 37.5% students reported that they had considerable knowledge of LICA (Question 2). Most students have limited understanding of LIGA before attending the course.

After this course, most students (92%) reported that the course content is more intensive than they expected (Question 3); 92% of students suggested that they could efficiently and effectively learn about LIGA from this course (Question 4); 62.5% students indicated that they have sufficient confidence to discuss related topics with others (Question 5). In addition, they suggested that they could read articles about LIGA after this class. Based on the statements above, in terms of course arrangement, students generally believe that the loading of theory introduction and experimental practice is appropriate, which could also trigger students' interests and pose considerable challenges for them. With regards to teaching materials and tools, the students proposed their opinions and feedback, as follows: only one student (4%) suggested that the course should include three additional points: 1) refine the course content; 2) discuss technology improvement methods; and 3) improve the processing equipment.

VII. Conclusions

The conclusions of this research are listed as follows:

1. The LIGA machinery operations practice can enhance the integration of teaching and practice.

2. Using easy-access tools to simulate LIGA operational processes can supplement the teaching of theories, strengthen students' understanding, and improve teaching quality.
3. Most students reported that they had acquired basic knowledge and operational skills upon completion of the course. The course also increases students' level of interests, which meets research expectations.

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