Process of a Prototype Design in Innovative Function

King-Lien Lee [*1], Jie-Wen Chen [2]

Department of Electro-Optic Engineering, National Taipei University of Technology, Taipei, Taiwan

[*1] kllee@ntut.edu.tw ; amigo.jewuen@gmail.com

***Abstract*- In order to make more functions of a systematic product, we have successfully innovated two different functional backlight modules by the theory of inventive problem-solving (TRIZ). To illustrate the process of a prototype design in innovative function, there are two case studies that an optical film is designed by innovative function processes and made the existing patent of a backlight module more advantageous.**

Keywords- TRIZ; Optical Film; Backlight Module

I. INTRODUCTION

Innovative functions of an enterprise are inducing a variety of products and enhancing competitiveness in a market. Thus, most enterprises invest a lot to increase applications of a product and decrease the cost of manufacture. By the theory of inventive problem-solving (TRIZ) [1, 2] and process of new prototype design [3, 4, 5], we propose the systematic process of innovation that can make engineers define problems correctly and find innovative solutions easily.

The systematic process of innovation is defined as the process of a prototype design in innovative function and is divided into primary innovation, secondary innovation, tertiary innovation, and so on. These stages are extensively identified to executive mechanisms for improving the harmful function of prototype and refining the technological innovation [6].

Our main goal is to understand how to innovate the existing patent of a backlight module by TRIZ. The first innovative goal is that this designed backlight module offers an oblique incident light source for the vertical-field-switching (VFS) blue phase liquid crystal display (BPLCD) [7]. The secondary innovative goal is that the designed backlight module offers an orientation and uniformity of luminance for light source of 3D LCD [8]. According different purposes, we can design different innovative functions of backlight module by choosing different inventive principles.

II. PROCESS OF A INVENTED PROTOTYPE DESIGN

Si & Lee discuss how to select the target patent under enterprise's strategy, before finally taking the designing around existing patent based on patent standardisation as a successful implementation of innovative process [9]. Hsu & Lee have developed several prototypes of products by making use of some analytical tools of the patent maps and TRIZ, and rules of patent infringement judgment [10]. Hu, Su, Lee, Chen, & Chang apply TRIZ methodology to assist product improvement that includes drawing patent maps, applying the methodology of TRIZ to analyze the problems, designing an improved folding bicycle [11].

Based on the previous studies, the systematic innovation could be divided into 7 steps (see Figure 1 for the steps). The innovative functions could be obtained by repeating the 7 steps.

In Fig. 1, stages of the systematic process of innovation are explained as follows:

A. Primary innovation:

1) Analyze the innovative object:

Select an innovative object for improving, and analyze the structure and mechanism of it.

2) List main independent items:

Analyze and draw relevant patent distribution and patent map to key technology, find out the necessary elements and the connection relation in the main independent claim of patent, convert the forming elements into functional terms and connect them for a system formed by main independent claims.

3) Define or recover harmful functions:

Hiatus, deficiency or improvement of patent that are in quoted patents of key patent or patents of the similar technologies are regarded as the harmful function.

4) List formulation problems:

The step contains to establish the cause-effect chart and list the question by narration. The established cause-effect chart is

a relation that links the system of main dependent items and the harmful function. The relation will be presented by narration.

5) Primary TRIZ:

According to the harmful functions of the innovative object, improvement and deterioration can be found. Using the corresponding engineering parameter and the contradiction matrix, the corresponding inventive principles can be obtained. From the inventive principles, we can draw inspiration of innovation. The processes of TRIZ are shown in Figure 2.

6) Evaluate by simulations or experiments:

The performances of the innovative result are evaluated by simulations or experiments.

7) Primarily new prototype:

If the innovative result can enhance performance, it can be regarded as the primarily new prototype.

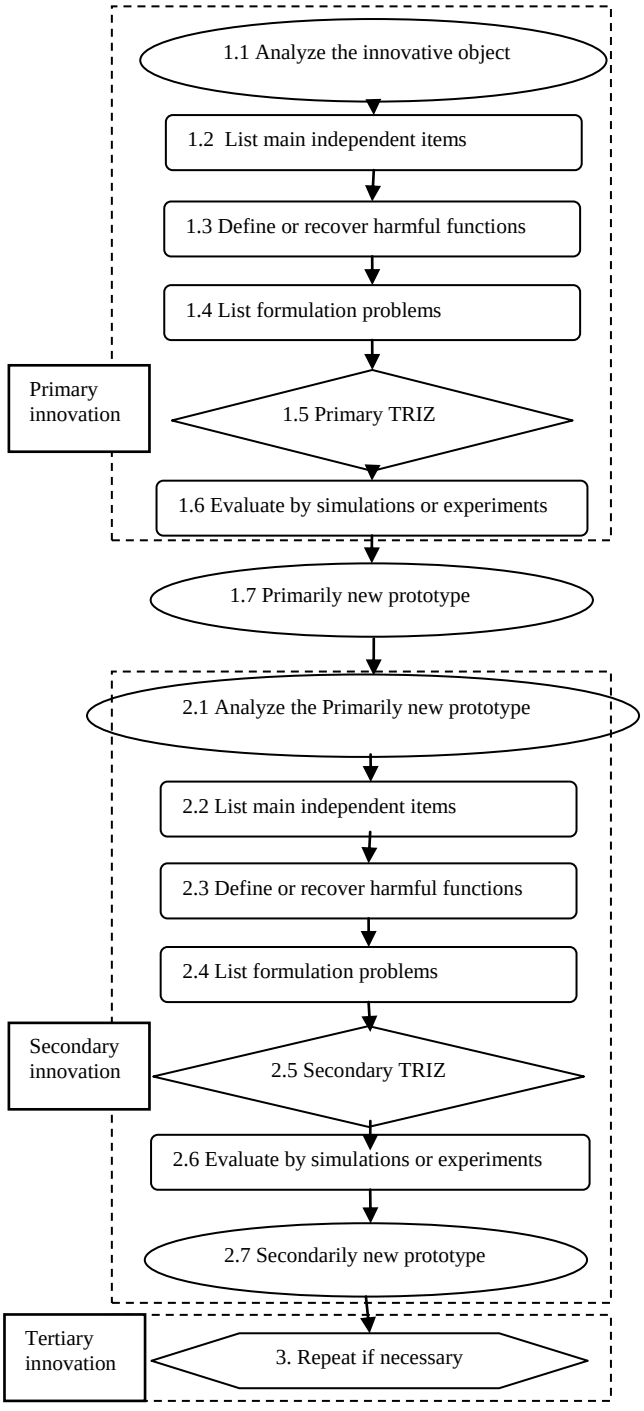

Fig. 1 Schematic diagram of the innovation process

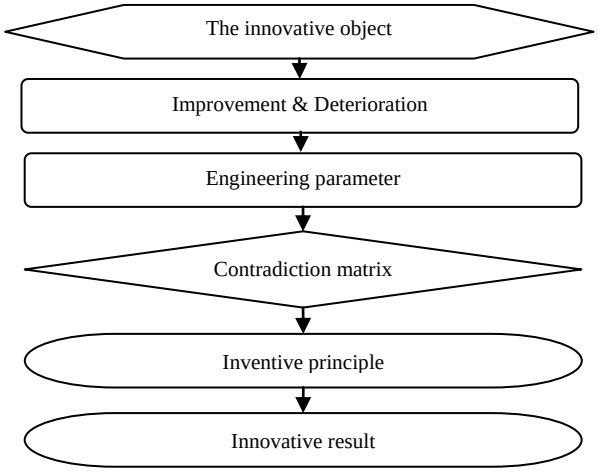

Fig. 2 Schematic diagram of the process of TRIZ

B. Secondary innovation:

To further enhance the performances, the primary new prototype can be regarded as a new innovative object. Repeating the 7 systematic steps of innovation, the secondary new prototype may be obtained.

C. Tertiary innovation

To further enhance the performances, we could regard secondary new prototype as a new innovative object. By repeating the 7 systematic steps of innovation, we would obtain the tertiary new prototype.

D. If necessary, we can repeat the systematic steps of innovation to obtain a refined prototype.

III. CASE STUDY

We select the existing patent of a backlight module for our case study.

A. Primary Innovation

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1) Analyze the Innovative Object:

The innovative object in this study is the existing patent of a 2.8-inch edge-lit backlight module (BLM) of a LCD [3, 12, 13]. Where, the BLM is composed of a light guide panel (LGP) which comprises many kinds of microstructures of V-grooves on both upper and lower surface, a reflective sheet, a light source reflector, four LED light sources on one width side of the LGP, a light source reflector, and a reflective sheet. The schematic diagram is shown in Fig. 3. According to the patent, we improve the uniformity of illuminance of the BLM.

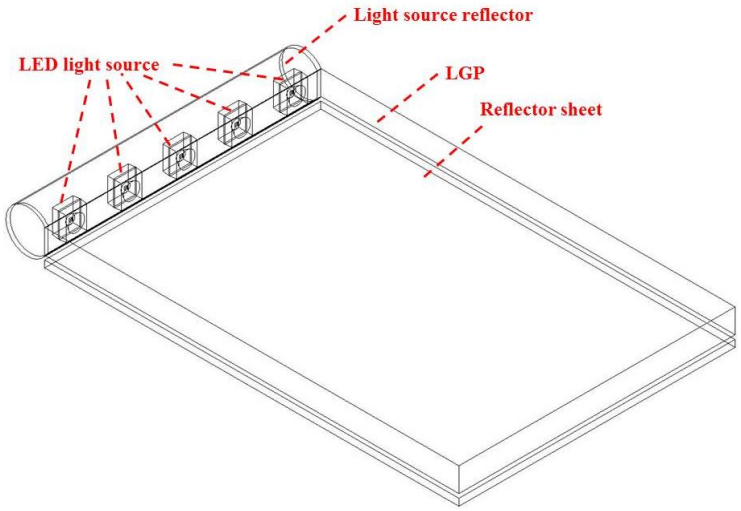

Fig. 3 Schematic diagram of the backlight module of the patent

2) List Main Independent Items:

Based on the structure of the BLM, the main independent items are listed in Table 1.

TABLE 1 MAIN INDEPENDENT ITEMS OF THE INNOVATIVE OBJECT

Item number	Component	Item number	Component
1	Light source	5	Reflective sheet
2	Light source reflector	5	Microstructure
3	LGP	6	Emitting surface

Thus, the constructed systematic frame of the main independent items of the innovative object is shown in Fig. 4.

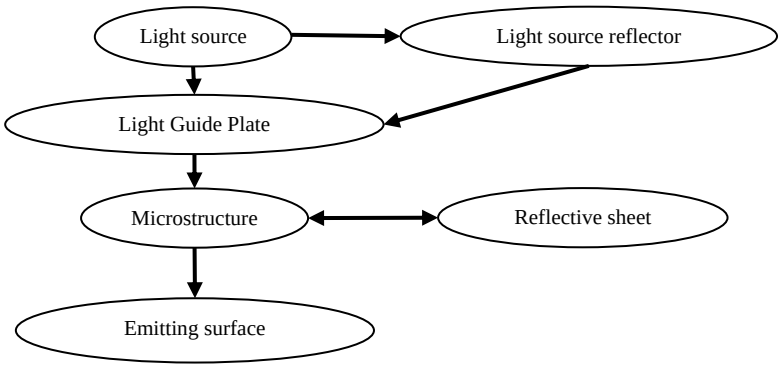

Fig. 4 Systematic frame of the main independent items of the innovative object

3) Define or recover harmful functions:

Conventionally, to enhance the uniformity of illuminance, there are two diffuser sheets set above the BLM. Moreover, to enhance effective luminous flux, two brightness enhancement films (BEF) are also set above the BLM. The schematic diagram is shown in Fig. 5 [14].

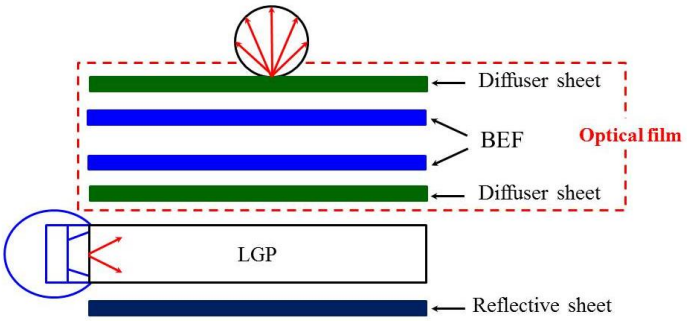

Fig. 5 Schematic diagram of the conventional backlight module and optical films

We substitute two brightness enhancement films (BEF) for one, and keep enhancing effective luminous flux function and make it have multi-direction function. However, setting four optical films above the BLM would make the structure complex. Thus, we define the harmful function as complexity of the device, and construct the cause and effect chart as shown in Fig. 6.

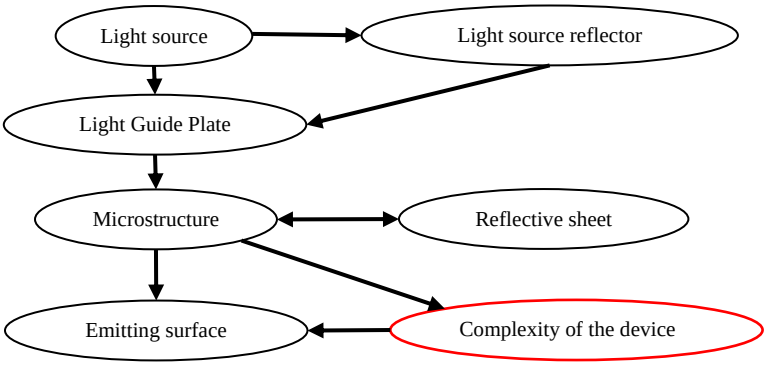

Fig. 6 Cause and effect chart of the innovative object

4) List Formulation Problems:

Accordingly, the formulation problem is how to enhance the uniformity of illuminance and the effective luminous flux in the situation of reducing the structure.

5) Primary TRIZ:

According to TRIZ, the corresponding engineering parameters are improvement (35) adaptability and deterioration (18) brightness. Then the corresponding inventive principles are: (6) universality, (22) blessing on disguise, (26) copying and (1) segmentation.

The purpose of this innovation function is for BPLCD which needs an oblique incident light source. We adopt the inventive principle (6) universality. Therefore, we construct the microstructures on the bottom surface of the optical film. The detail of optical film is shown in Fig. 7.

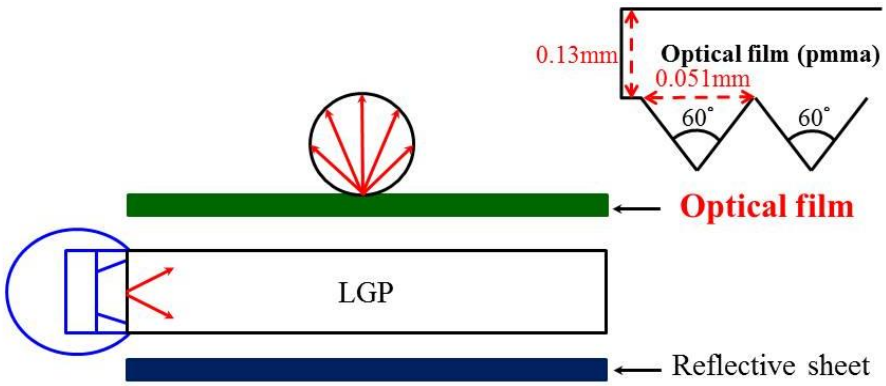

Fig. 7 Schematic diagram of the microstructures of V-grooves on the bottom surface of the multi-functional optical film

According to previous reports, the uniformity of illuminance is usually evaluated by 13-points detection, as shown in Fig. 8.

Taking both the length and width of the optical film as invariables, the multi-functional optical film is included into only one zone. We name it "Whole design." Then, we construct uniform micro-structures on the upper surface of the BLM.

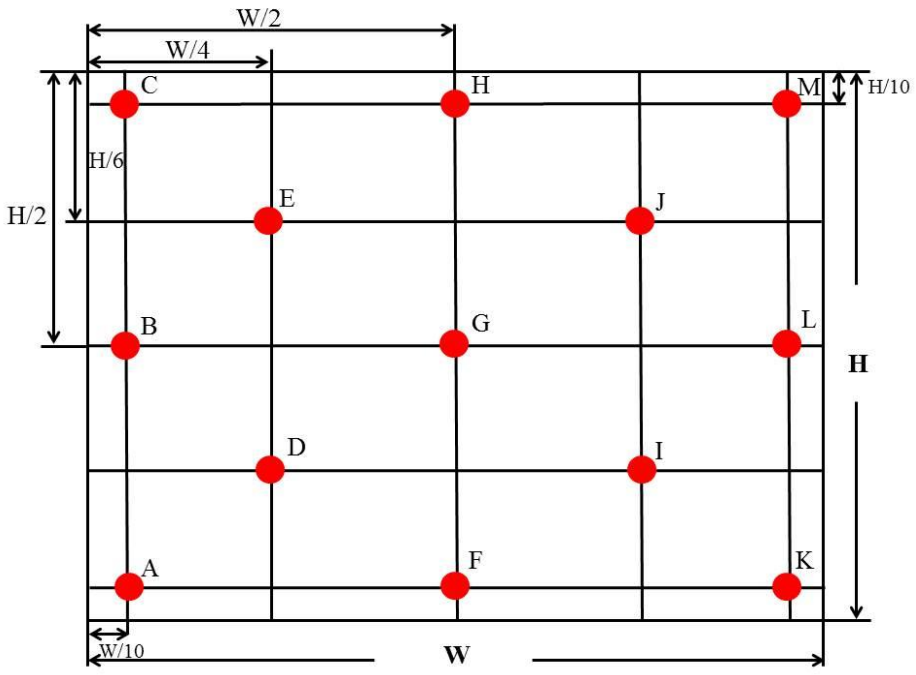

Fig. 8 Schematic diagram of the positions of the 13-points detection [15]

6) Evaluate by Simulations or Experiments:

The optical performances of the optical film are evaluated by optical simulation software, TracePro™. Figure 9 shows that the angular distribution has a single peak before adding the optical film and then separates into two peaks by the optical film. The uniformity of illuminance results are listed in Table 2.

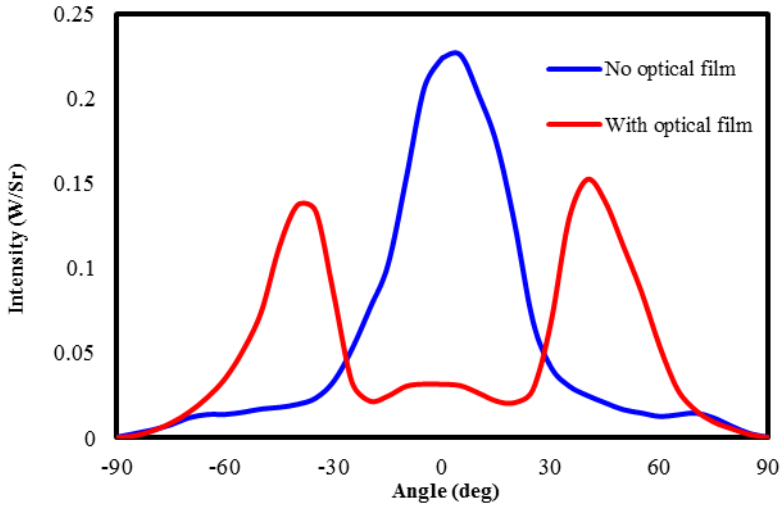

Fig.9 Cause and effect chart of the innovative object

TABLE 2 THE OPTICAL PERFORMANCES OF THE OPTICAL FILM

Type	Uniformity of illuminance
No optical film	75.78%
With optical film	65.81%

7) Primarily New Prototype:

This backlight module has orientation function by this optical film.

B. Secondary Innovation

1) Analyze the Primarily New Prototype:

We have proposed the optical film with the apex angle 60 °and we will repeat the 7 systematic processes of innovation.

2) List Main Independent Items:

Based on the primarily new prototype, the main independent items are listed in Table 3.

TABLE 3 MAIN INDEPENDENT ITEMS OF THE PRIMARILY NEW PROTOTYPE

Item number	Component	Item number	Component
1	Light source	5	Reflective sheet
2	Light source reflector	5	Microstructure
3	LGP	6	Optical film
		7	Emitting surface

Thus, we constructed the systematic frame of the main independent items of the primarily new prototype, as shown in Fig. 10.

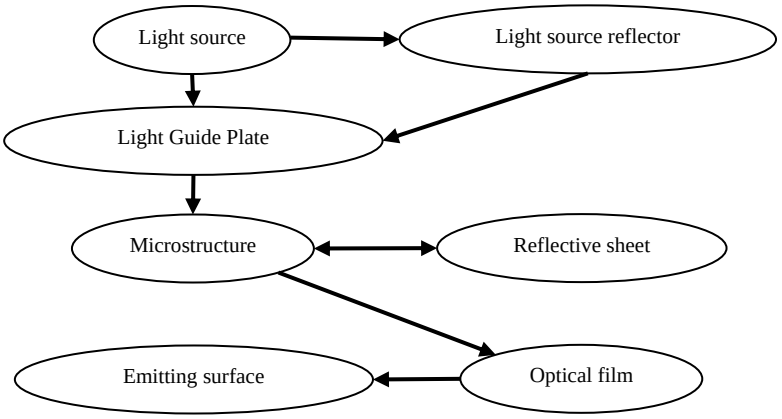

Fig. 10 Systematic frame of the main independent items of the primarily new prototype

3) Define or Recover Harmful Functions:

Setting the optical film above a BLM may redirect the light, but uniformity of illuminance decreased. Thus, we defined the harmful function as decreasing performances, and construct the cause and effect chart as shown in Fig. 11.

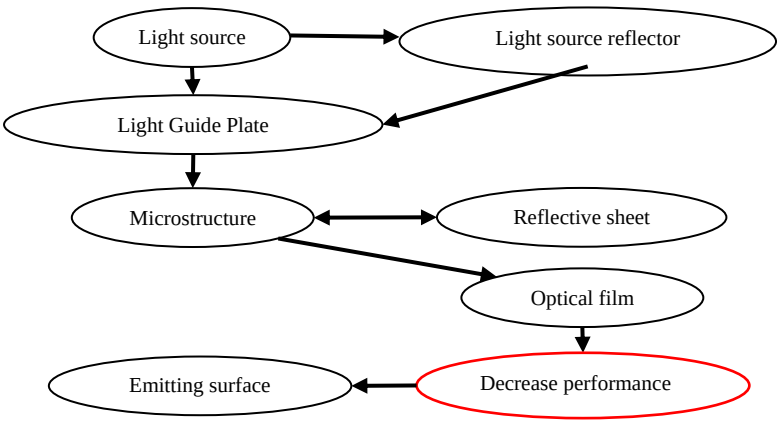

Fig. 11 Cause and effect chart of the primarily new prototype

4) List Formulation Problems:

Accordingly, the formulation problem is that how to part of the light but also enhance the uniformity of illuminance.

5) Secondary TRIZ:

According to TRIZ, the corresponding engineering parameters are improvement (18) brightness and deterioration (36) complexity of device. Then, the inventive principle: (6) universality, (13) inversion and (32) changing the color.

We adopted inventive principle (13) inversion, and constructed many kinds of microstructures of V-grooves closely on the bottom surface of the multi-functional optical film. Additionally, the parameters of apex angles and arrangement orientations of the V-grooves may be changed. Then it can be found that setting just one multi-functional optical film above a BLM would enhance not only effective luminous flux but also uniformity of illuminance. The schematic diagram of microstructure is shown in Fig. 12.

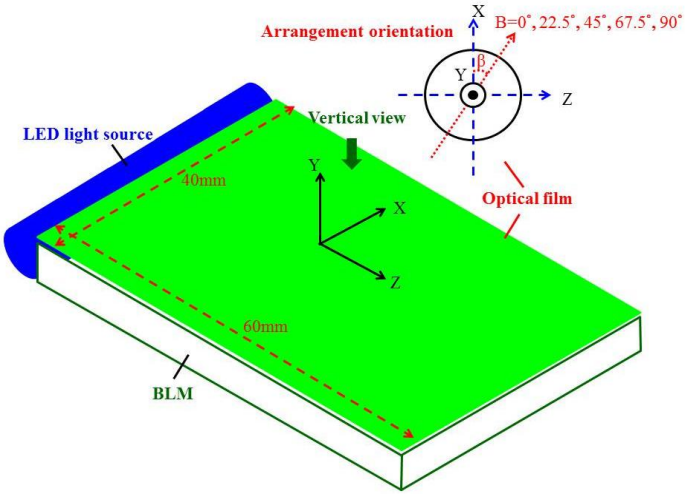

Fig. 12 Schematic diagram the rotation angle of V-grooves on the bottom surface of the multi-functional optical film

6) Evaluate by Simulations or Experiments:

We evaluate the optical performances of the multi-functional optical film by the optical simulation software, TraceProTM. The uniformity of illuminance results are listed in Table 4.

TABLE 4 THE OPTICAL PERFORMANCES OF THE ROUGH PARTITION DESIGN

Type	β	uniformity of illuminance
With optical film	0 °	65.81%
	22.5 °	68.13%
	45 °	70.11%
	67.5 °	75.28%
	90 °	75.95

7) Secondarily new prototype:

Accordingly, the optical film with the apex angle and the arrangement orientation angle as shown in TABLE IV can enhance the performances. The innovative result is the secondarily new prototype in our study.

C. Tertiary Innovation

The systematic processes of the tertiary innovation are the same with the primary innovation. The purpose of this innovation function is for 3D display which needs an oblique incident light source for right and left eyes. We adopt the inventive principle (1) segmentation. Figure 13 shows the apex angle divided into θ_1 and θ_2. The emitted light angle can be controlled by different θ_1 and θ_2. The detail is schematized in Fig. 14.

The innovative result is the tertiary new prototype and the tertiary new prototype is also the refined prototype design in our study.

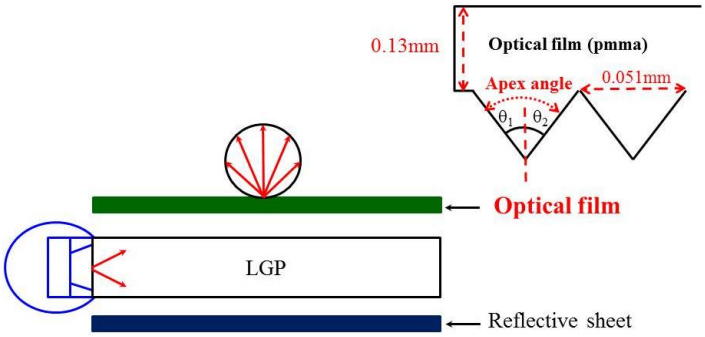

Fig. 13 Schematic diagram the apex angle of the multi-functional optical film which is the combination of θ_1 and θ_2

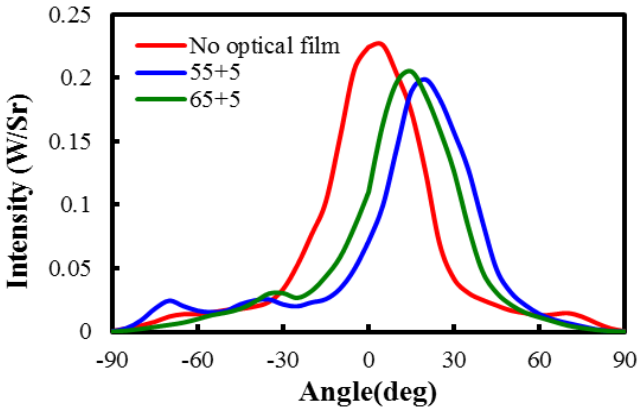

Fig. 14 Schematic diagram of the apex angle design

IV. CONCLUSIONS

We have developed the novel systematic process of innovation by the theory of inventive problem-solving and systematic controlling variables method of new prototype design. According to different research purposes, the systematic innovation could design different innovative functions of backlight module by choosing different inventive principles. Those principles reduce to the primary innovation, secondary innovation, tertiary innovation, and so on. The systematic process of innovation will make research and developments more efficient as well as cheaper.

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King-Lien Lee received the M.S. degree in physics from National Taiwan Normal University (NTNU) in 1980, and received the Ph.D. degree in Graduate Institute of Science Education from NTNU in 1999. He is a Professor of Electro-Optical Engineering at National Taipei University of Technology. His research interests backlight system, industry trend analysis and innovations of new prototype design.

Jie-Wen Chen received the B.S. degree in physics from Soochow University in 2008. She is currently working toward the M.S. degree at the electro-optical engineering, National Taipei University of Technology. Her current research interest includes backlight module design.