

Strategic planning of developing automatic optical inspection (AOI) technologies in Taiwan

K C Fan¹ and C Hsu²

¹Department of Mechanical Engineering, National Taiwan University, Taipei 106, Taiwan, CHINA

²Centre for Measurement Standards, Industrial Technology Research Institute, Hsinchu 300, Taiwan, CHINA

Email: fan@ntu.edu.tw

Abstract. In most domestic hi-tech industries in Taiwan, the Automatic Optical Inspection (AOI) equipment is mostly imported. In view of the required specifications, AOI consists of the integration of mechanical-electrical-optical-information technologies. In the past two decades, traditional industries have lost their competitiveness due to the low profit rate. It is possible to promote a new AOI industry in Taiwan through the integration of its strong background in mechatronic technology in positioning stages with the optical image processing techniques. The market requirements are huge not only in domestic need but also in global need. This is the main reason to promote the AOI research for the coming years in Taiwan. Focused industrial applications will be in IC, PCB, LCD, Communication, and MEMS parts. This paper will analyze the domestic and global AOI equipment market, summarize the necessary fish bone technology diagrams, survey the actual industrial needs, and propose the strategic plan to be promoted in Taiwan.

1. Introduction

In the past two decades, traditional industries have lost their competitiveness due to the low profit rate. Meanwhile, due to the advent of emerging technologies, many hi-tech new industries have replaced them in the key role of promoting the Taiwan economy growth, such as the IC, PC/NB, LCD, communication, NEMS, etc. Table 1 classifies the difference in characteristics of conventional and emerging industries [1]. In those hi-tech industries, in addition to the main in-line fabrication equipment, the off-line inspection equipment is also indispensable to guarantee product quality. In order to detect the dimensions and the defects of the hi-tech components, in accordance with the trend of high throughput and high resolution, the AOI equipment is the necessary tool.

In most domestic hi-tech industries the AOI equipment is imported. In view of the technology need, AOI consists of the integration of mechanical-electrical-optical-information technologies. It is possible to promote a new AOI industry in Taiwan through the integration of its strong background in mechatronic technology in positioning stages with the optical image processing techniques. The market requirements are huge not only in domestic need but also in global need. This is the main reason to promote the AOI research for the coming years in Taiwan. Focused industrial applications will be in IC, PCB, LCD, Communication, and MEMS parts. This paper will analyze the domestic and global AOI equipment market, summarize the necessary fish bone technology diagrams, survey the

actual industrial needs, and propose the strategic plan to be promoted in Taiwan.

Table 1. Characteristics of conventional and emerging industries

Characteristics	Conventional Industries	Emerging Industries
Types of industry	Machine tools, moulds, textile, car, mechanical part, etc.	parts, modules, IT products, ODM, OEM, customer brand name.
Types of Product	Equipment, Modules, Brand name.	IC, PC/NB, PC peripheral, FPD, Telecommunication, Mobile phone, Optoelectronics, etc.
Capital	US\$ 1M to US\$ 30M.	US\$ 30M to US\$ 30B
Production equipment	Mostly domestic made	Mostly imported
Quality inspection	Sample inspection	100% inspection
Technology required	Manufacturing, mechatronics, automation.	Micro/nano process technologies, opto-mechanical-electro integration, automation
Accuracy	Medium to high	High to ultra high
Revenue	US\$ 10M (major) to US\$ 10B (minor)	US\$ 100M (minor), US\$ 1B (major) to US\$ 100B (minor)
Market competitiveness	decreasing	increasing
Human resource	Needed but difficult	Urgently needed but easy

2. AOI market

According to the ITIS survey, the global AOI equipment market is about 3.7 billion US dollars in year 2004, and it will gradually increase to 6.5 billion US dollars in 2006, as shown in Fig. 1. Some emerging industries take the major share of AOI market, as shown in Fig. 2 [2]. It is known that there are many OEM industries fabricating systems and components for many world leading companies, such as IBM, HP, Dell, Motorola, Nokia, etc. The AOI equipment purchased in Taiwan in the year 2004 has reached US\$ 1 billion, and it is forecasted to reach US\$ 1.4 billion in 2006. The annual report shows that in year 2004 the overall domestic made AOI equipment was less than 10% of the total domestic market. It is expected that there will be a large space for local AOI industry in the coming years.

3. AOI Core technologies

Fundamental AOI technology consists of the following subsystems: (1) precision motion controlled XY-stage, (2) optical-mechanical system, (3) image capture and processing system, and (4) image analysis and error detection system. Applications all relate to dimensional measurement and defect detection. Fig. 2 summarizes the necessary technical bone diagram for 2D applications, and Fig. 3 illustrates the 3D AOI technical bone diagram [3]. There are also some other important technologies, such as AXI (X-ray), OCT (optical coherence tomography), spectrum microscopy, etc. to be noted.

4. Strategic planning

4.1. AOI Forum

The first voice promoting the domestic AOI industry was that of the authors to local industries, academia, and government research institutes. In December 2001, the first AOI Forum was held at National Taiwan University with 50 invited participants from various sectors. In May 2002, the second AOI Forum was continued with more than 200 participants, including government officers and members of parliament. The third Forum was held in May 2003 at which more consolidated decisions

were made and focused on the IC, PCB, FPD, and opto-electronic AOI equipment development.

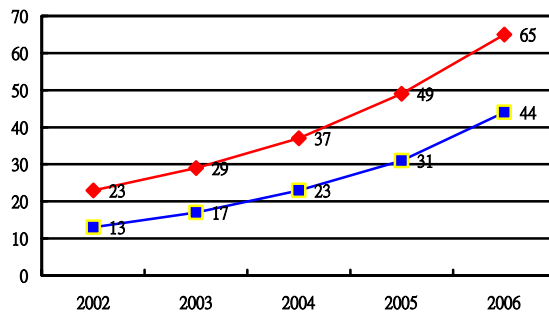


Figure 1. Global AOI market (♦: value in US\$ 100M, ■: number of system in million).

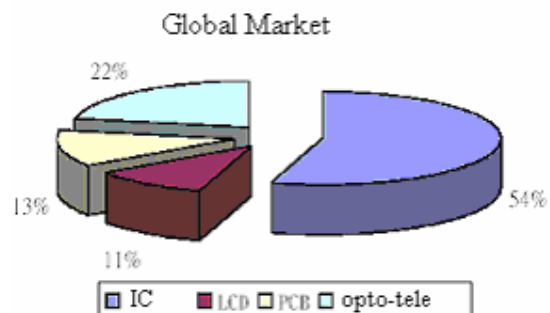


Figure 2. Global AOI market share.

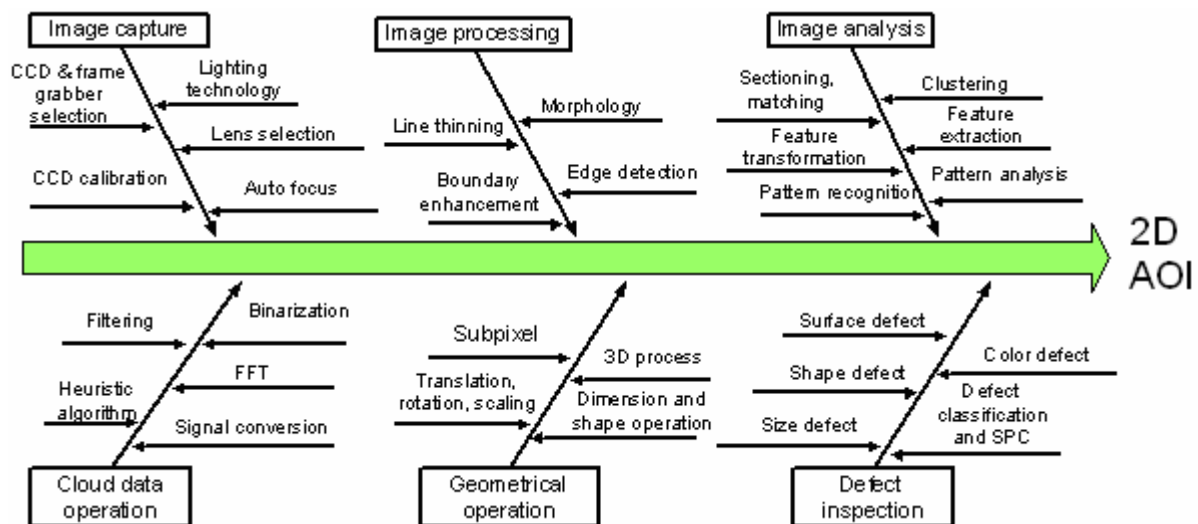


Figure 3. Technical bone diagram of 2D AOI.

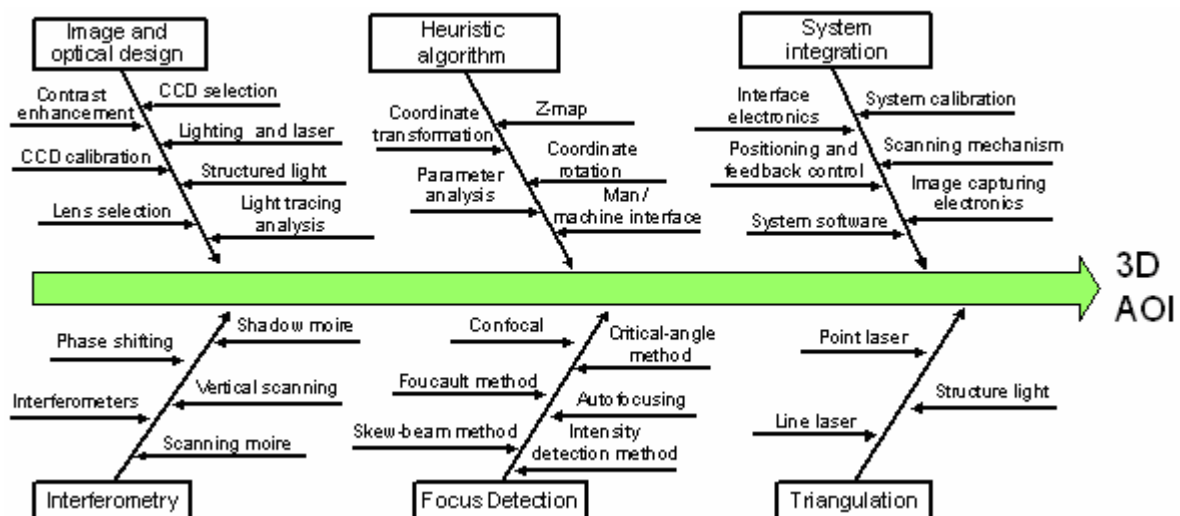


Figure 4. Technical bone diagram of 3D AOI.

4.2. AOI Association formation

From the progressive steps of AOI Forum promotion, the time came in March 2004 at which a formal AOI Equipment Association (AOIEA) was established [4]. Four working groups were formed in IC, PCB, FPD, and opto-electronic areas, each with a group leader from respective AOI maker. In the meantime, the first author was invited by the government to draft the white paper of AOI strategic plan. This national program was launched in January 2005 sponsored by the government R&D budget.

4.3. AOI developing strategies

The task force of each working group is to form a strategic alliance among several relevant AOI equipment makers and users. Each alliance will propose an integral proposal to apply the government R&D sponsorship. Some common core technologies will subcontract to research institutes for in-depth long period development, such as in image processing software, lighting analysis, and precision XY-stages. Industrial applications are focused on the following subjects: (1) 2D measurements— such as line/pin width/spacing, ball/hole diameter/position, mask alignment, and geometrical analysis, etc. (2) 2D defect inspection— such as pattern recognition and defect classification for all areas, (3) 3D measurement— surface profile measurements for meso-, micro-, and nano-scales, such as the thin film thickness, spacer or ball height, substrate warpage, micro optics, grooves, and free-form shapes, (4) 3D defect inspection—such as inner defects detection using X-ray, OCT, fluorescent light, etc. techniques for PCB, solder, BGA, etc.

The government's role is very important to promote the birth of a new AOI industry. The annual program budget will be allocated by each related ministry. The Ministry of Economic Affairs takes the responsibility to invite AOI users to provide a β -site test environment. The Ministry of Education and the National Science Council will launch an ad hoc committee to encourage university/industry collaboration. It is expected that by year 2008 the domestic production of AOI equipment can reach 30% of the global market total.

5. Conclusions

This article briefly describes the market and technology needs of AOI equipment, and its strategic plan recently developed in Taiwan. The work force has been carried out since 2001. With active involvement by the industry and research institutes the government finally joined in and set up a new policy to promote the new AOI industry. The driving force is continually generated under the leadership of the AOI Equipment Association (AOIEA), which has collected more than 200 members and established a dynamic platform in its web site (<http://aoiea.itri.org.tw>).

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