

Case Study Computer Vision in the Clean Room

ROLL-OUT OF INTEGRATED DEFECT DETECTION

HTL uses Image Processing to help leading Flat Panel Display Manufacturer improve Defect Detection

When minutest of defects can damage a manufacturer’s productivity and profitability, every step in the process matters. HTL and the client company partnered to launch an inspection system that improved inspection accuracy and helped reduce time and labor cost due to manual inspection and recalls.

Semiconductor device fabrication* is the process used to manufacture semiconductor devices, typically the metal-oxide-semiconductor (MOS) devices used in the integrated circuit (IC) chips that are present in everyday electrical and electronic devices. It is a multiple-step sequence of photolithographic and chemical processing steps during which electronic circuits are gradually created on a wafer made of pure semiconducting material. A **photomask*** is an opaque plate with holes or transparencies that allow light to shine through in a defined pattern. They are commonly used in photolithography and serve as templates for device manufacturing.

Mask inspection* plays a pivotal role in current high-grade mask making processes and further its importance is getting bigger. The purpose of inspection process is two-folds. One is simple sorting of masks that have fatal defects with high sensitivity. The other is improvement of total mask manufacturing process and mask quality using defect source analysis. As semiconductor devices are getting shrunk down, the influence of mask defects is increasing. Therefore, there are special needs for the efficient use of such expensive inspection machines and the systematic approach of defect analysis. In general, Inspection process is divided by

two steps. One is detection of defects and the other is review for defect analysis.

Problem:

When defects go undetected or leave the manufacturing plant, the costs are high – customer costs, product scrapping and entire batches being defective can damage brand and loyalty. Time-consuming manual defect inspection can lead to increase in time and labor cost and recalls.

Background:

The end customer in Japan, a leading manufacturer of flat panel displays (FPD), wanted a consistent production of high resolution, better image quality large-screen LCDs. They understood that the photomasks* which were the foundation for their manufacturing process for FPD needed to be completely defect free and wanted to invest in a Mask inspection* tool and software that would help achieve that. Any mismatch or error could lead to a defective product.

Our client based out of Japan, is involved in the manufacture, sales, and service of electronic equipment for the Flat Panel Display (FPD) and Semiconductor Industry*. Their Photomask* Equipment serve the purpose of inspection, repair, and measurement of photomasks. Their Mask Inspection* equipment for FPD's, is an indispensable device and plays a critical role in identifying defects and shortening the time to production of FPD's for their clients.

Business Challenge:

Transform the Inspection Process by synchronizing all the devices, tools, and processes to create seamless defect detection.

HTL has been involved in this project with their photomask inspection equipment.

Our client manufactures the machines that help write, inspect, and repair the photomasks. The Mask Writers help write circuits onto the photomask. Thereafter, there is a need to verify the print is in complete conformance with the original CAD design. The inspection machine manufactured by our client helps detect any mismatch in the patterns which may exist between the mask and their CAD (computer aided design) files.

This involves inspection of the photomask in real time and thereafter identification and classification of any defects for repair.

Photomasks are the first step in the assembly plant to manufacture the displays. These are very large masks for 60 inch and larger LCDs and our client's inspection machine is one of few machines able to detect such defects.

Solution:

HTL project team supported our client to simultaneously build and synchronize the Vision Software needed to communicate with the hardware being installed at the plant and meet specifications. The [HTL Computer Vision Solution](#) involved among others, synchronizing imaging equipment along with computer vision algorithms accelerated by imaging library. The

solution runs on Industrial PCs at the edge using high-performance CPU. The image data is collected and stored by the imaging system and transmitted using local area networks to edge devices using real-time detection for analysis by software. The solution had the following main components:

Imaging System: The solution along with client hardware involved combining imaging equipment and Image Processing Algorithms to capture and compare the images in real time.

- *Data conversion* from CAD to image.
- Enable *Image Processing* PC connected by LAN to analyze live images captured by TDI Cameras and compare them with CAD converted images.
- *Superimpose* live images from 2 review cameras onto one channel buffer and enable user display on window.
- Capture and save images during *Macro Scan* of photomask.
- Implement defect image cut and store during *Line Scan* of large stripe image.
- Static image display: Load the static image and perform *offline transforms* (Rotate, flip) and display on window.

Edge Equipment: The equipment used were Database, Image Processing, and Defect Processing PC's, Main Mask PC, monitor for viewing and interface, and CAD and Defect Data servers for data storage all connected by LAN and high-speed optical fiber cable. The Image Processor PC helped compare and detect any mismatched patterns between the live image and CAD design

Software: Image Processing Library for defect inspection and Defect Analysis and Data conversion algorithms. The Defect Processing Algorithm helped identify and classify the defects for analysis and repair. Images were stored in the 'Defect Processing PC'.

Technologies:

Database PC

TDI Camera

Defect Process PC

Image Processing PC

Imaging Library

VC++  , Linux 

Inputs the CAD design and processes design data

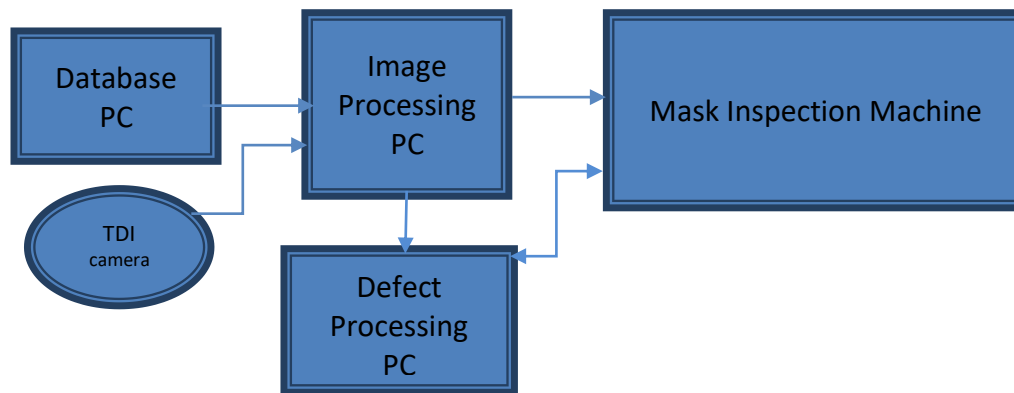
Captures images of the photo mask in real-time

Captures defects based on output received from Image Processing PC

Optical fiber for high speed communication,

Compares the live images in real-time with the database design

Part of Image Processing tool - comparing live image of photomask with Data base images converted from CAD design to image. Obtain live image of photomask in real time and compare with converted images from CAD design



Results:

The different processes and equipment were synchronized to achieve high accuracy. Some of the solution features in image processing executed:

- ✓ Identify and classify edge detection, corner detection defects on mask.
- ✓ Execute Image transformation techniques- [scale, skew, rotation, flip, brightness, contrast etc.].

- ✓ Apply Image filters - [Gaussian, Bilateral etc.].
- ✓ Interface TDI macro, CCD cameras and display live images from these cameras onto user device.
- ✓ Customize the Algorithms to dynamically recognize and isolate defective images from live feed in real time.

The solution implemented was much faster than manual inspection. It helped save time and errors arising from inconsistency and human subjective observation. This reduced recalls and rework which in turn helped keep up with production line demand thereby increasing efficiency and revenue.

HTL has further engaged in providing their Image Processing Solution for the next line of Inspection machines series 2 and 3. The roll- out of integrated defect detection helped save on long training times for personnel for inspection, reduce inefficiency and fatigue, and do away with inconsistency arising from human error. The solution can run continuously and provides consistent results that are reliable.

HTL's Computer Vision Solution:

HTL has capability in the field of Image Processing and computer vision solutions. Its multiple projects in this space have enabled:

- Interfacing with imaging equipment and library and design/execute algorithms.
- Defect Detection and analysis
- Feature Detection: Some of the key areas are
 - Edge Detection
 - Corner Detection
 - Blob Detection
 - Ridge Detection
- Image Recognition
 - Still Picture
 - Motion Picture

[Read to find out More](#)
HTL's Image Processing Solutions

Automated Product Inspection, Defect Detection, Pattern Matching, Quality Monitoring, Optical Measurement, Throughput Enhancement, Analysis and Display for Insights and Productivity.

About HTL:

HTL Company Japan Ltd. is a global provider of unique customized solutions in the semiconductor and manufacturing industry. Established in 1994, their portfolio includes hardware and software solutions. Their hardware solutions include equipment for semiconductor and FPD mask making, additive manufacturing, strategic material deposition, scanning acoustic microscope, specialized purposes such as small satellite electronics and security monitoring as well as chemical materials. Their system integration software solutions have helped their customers with solutions in image processing, equipment automation, remote monitoring, device communication, web applications as well as EDA applications.

*Sources:

Novel mask inspection flow for better defect review and analysis

Photomask and Next-Generation Lithography Mask Technology XIII. Edited by Hoga, Morihisa. Proceedings of the SPIE, Volume 6283, id. 62830Z (2006).

Wikipedia <https://en.wikipedia.org/wiki/Photomask>



HTL USA, Inc. 1671 Dell Avenue, Suite 210
Campbell, CA 95008
Tel: +1 408 628 0465
Toll Free No: 1-888-htlusa1
Email: info@htlusa-inc.com
www.htlusa-inc.com

HTL Co. Japan Ltd.
3F Techno Building, 2-16-6 Akebonocho
Tachikawa, Tokyo, Japan 190-0012
Tel: 042-523-2871
Email: htl@htlco.co.jp
<http://www.htlco.co.jp/indexEng.html>

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