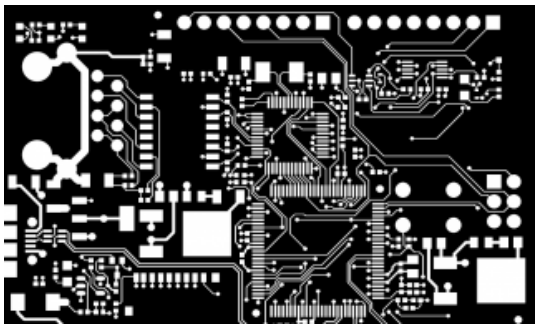
White Paper

High Performance Projection Engines for 3D Metrology Systems

www.lumaxis.net
Lumaxis, 11495 Sunset Hills Rd., Ste. 106, Reston, VA 20190

Introduction

3D optical metrology using structured light projection (SLP) is now a well established technique for the rapid gathering of 3D coordinate details of a device under test (DUT). The technique is completely non-contact and lends itself to Solder Paste Inspection (SPI), microelectronics inspection (MEI), and Automated Optical Inspection (AOI) of manufactured parts for inline assembly processes and of small (molded) parts. In such applications, the whole surface height distribution of the DUT can be calculated and compared with a reference in seconds.



Many leading manufacturers of 3D metrology systems design and manufacture their own projection-engines. However, typical SPI/MEI/AOI companies have limited optical design experience and as a result, design and development timelines can drag on for several months before reaching acceptable performance levels. Some companies sub-contract optical design out, but do not consistently achieve the desired levels of performance; once the optical design is fixed, the variation can only come from SLP manufacturing tolerances.

Lumaxis provides projection engines that it designs into 3D metrology solutions, focusing primarily on automated optical inspection systems. Lumaxis gives manufacturers serving the electronics market an industry-leading combination of resolution, speed, precision, reliability, and design flexibility.

This white paper provides a concise overview of SLP technology (and its performance characteristics; a section on the state-of-the-art in Projection Engine (PE) technology; the various challenges in developing and integrating PEs into existing optical inspection systems; and the advantages that accrue to manufacturers that outsource PE design and manufacturing.

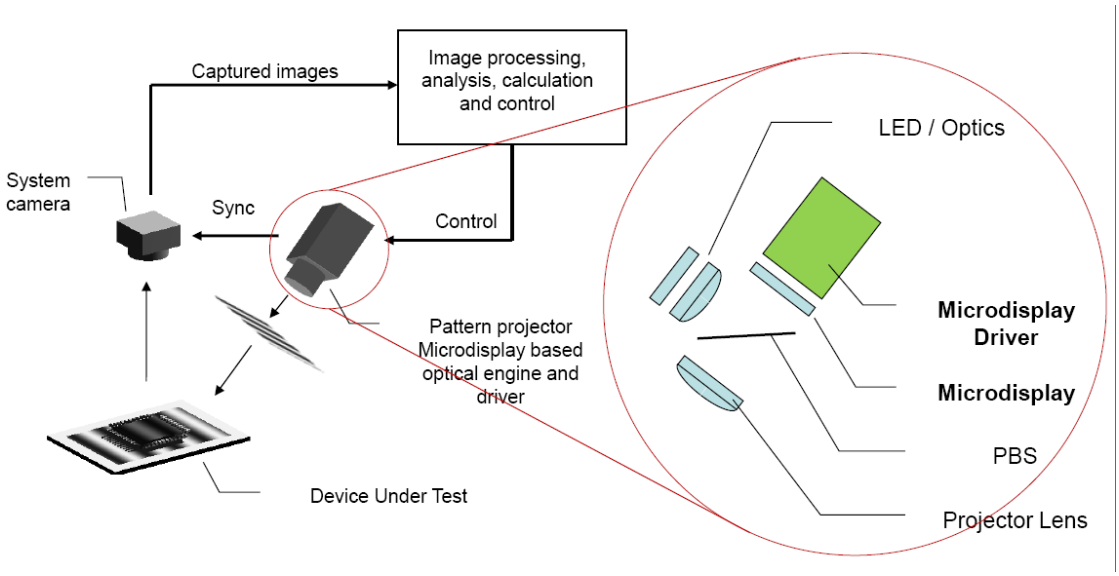
These include:

- Potentially better desing and performance consistency due to extensive experience with specialized skillset.
- Flexibility, agility, and reduced risk that comes from outsourcing.
- Enabling AOI machine manufacturers to focus on their core competencies, saving them time and money

Lumaxis Inside: The Technology and How it Works

A. Overview of Structured Light Projection (SLP)

Structured light metrology is a method where a known pattern is projected onto an unknown surface and by analyzing the deformation (warping) of the known pattern, one can mathematically reconstruct the surface virtually. SLP incorporates the principle of triangulation to determine the x,y,z location of a specific point in space and uses algorithms to then stitch together a set of points to form a point-cloud and subsequent 3D image with actual numerical dimensions assigned to the Device Under Test (DUT).



The projectors projects an area that is usually smaller than the DUT. The projected area is often called Field of View (FoV), and will have certain brightness and relative contrast ratio requirements. SLP offers the best potential for achieving design goals such as speed, accuracy and cost.

B. Lumaxis Projection Engine

A structured light 3D optical metrology system typically consists of a projection unit or engine, image acquisition unit (camera) and a processing/analysis unit. Synchronization between the projection unit and the camera is important for accurate and efficient image capture. The workflow for such systems usually consists of the following steps: (1) one time system calibration using calibration patterns, (2) projection and capture of structured light patterns, (3) pattern decoding/fringe analysis-phase unwrapping and (4) 3D co-ordinate calculation/height mapping and point cloud construction.

The set of patterns for the structured light is linked to the processing techniques used to calculate the 3D coordinate data, and the application parameters such as accuracy, measurement cycle time, and DUT surface characteristics. Typically, the patterns can be either a series of 1-bit Gray code stripe patterns, or a series of sinusoidal n-bit greyscale patterns (used for phase shift techniques where the projected pattern is phase modulated by the DUT height distribution). Sometimes a system may use a combination of both. While various solutions for image projection exist, a microdisplay-based projection engine is particularly well suited for the application of structured light projection in 3D optical metrology. A microdisplay-based solution to structure in the projected light into stripe patterns enables a high resolution limitless pattern variation, allowing flexibility in pattern/algorithm design. Forth Dimension Displays' QXGA (2048 x 1536 pixels) microdisplay used in Lumaxis PEs is a high resolution Spatial Light Modulator (SLM) particularly well-suited for creating structured light patterns in an off-axis configuration fulfilling the Scheimpflug condition. The Scheimpflug condition enables a horizontal focal plane while the PE is set an angle around 30°.

The microdisplay is binary in nature (each pixel is only ever on or off). Pixel intensity is created using pulse width modulation (PWM) resulting in a linear greyscale response. This is particularly important for techniques employing sinusoidal phase-shifted patterns. Further, as the microdisplay is a reflective device, all the pixel circuitry is located behind the pixel mirror enabling a very small in inter-pixel gap (or high 'fill-factor'). The fill-factor of the Forth Dimension Displays' QXGA display is >94% enabling the projection of high fidelity images with little discernable pixel structure. These microdisplays offer a further advantage of high speed which allows faster 3D measurements without loss of precision.

C. Deployment Models

While PE design and manufacture is a critical component of 3D optical inspection system, camera selection, camera lens design, image capture and construction algorithms as well as mechanical structure design are all variable parameters which impact target applications and addressable markets. Levels of performance of PE, cameras, lenses and algorithms must be matched to achieve an efficient and robust final product output.

Early adopters of 3D optical inspection technology have extensive internal capabilities, allowing them to design and deploy their own projection engines. However, by 2014, later adopters lacked this depth or breadth of internal expertise required to develop their own projection engines.

Case in point: several years ago, one prominent manufacturer developed their own PE; it took them well over 3 years to develop, and it never met all of the performance targets. There are several SPI and AOI device manufacturers that address higher-end applications and niche markets in the US and around the world. Suppliers of in-line production SMT (Surface Mount Technology) measurement machines are looking to develop new technology and machines that raise the bar in the “state of the art.”

Lumaxis has a unique advantage in addressing the majority of performance requirements needed from structured light projectors, based on its experience in using ForthDD products in compact, low weight high performance direct view and projected image applications.

Permitting the action will take a while for completion.

D. Competitive Advantages

The following are the key factors that differentiate Lumaxis from its competion:

- By focusing exclusively on designing high-performance PEs Lumaxis is able to deliver high quality projection engines within months – versus years – enabling manufacturers to bring high-end optical inspection machines to market in a more efficient manner

- Lumaxis PEs optimize the performance of existing hardware (better resolution, depth of vision/field, brightness, size, weight, etc.) by leveraging extensive experience in LCoS (Liquid Crystal on Silicon) microdisplay based compact PE design.

- Lumaxis gives manufacturers the flexibility and agility that comes from outsourcing.

- Proven ability to deliver: Lumaxis is a division of NVIS, Inc., with 15+ years of using Forth Dimension Displays LCoS mircodisplays in compact, low weight, high performance near-eye and projected image applications.

Specifications

Lumaxis SLP Q252 Specifications | REV 7 | Jan 2018

Parameter	Specification	Units	Description
Field of View (FOV)	41 X 35	mm	Size of the projected image
Resolution	25	line-pairs/mm	Maximum number of alternating black and white line pairs per millimeter in the projected image
Illuminance	1300	Lux	Luminous flux (Lumens) incident per square meter of projection area
Contrast	280:1	-	Ratio of white image luminance to black image luminance
MTF	>0.1 (@25lp/mm)	-	Modulus of the optical transfer function at maximum resolution
Depth of Focus	5	mm	Depth for which projected image remains in focus at maximum resolution
Throw Distance	194 ± 2.5	mm	Projected image distance from the projector
Tilt Angle	30.6	Degrees	Angle between projector axis and vertical axis (angle of incidence)
Microdisplay Technology	Liquid Crystal on Silicon 2048 X 1536 Forth Dimension Displays	- Pixels -	Microdisplay Type Resolution Manufacturer
Mass	1340	Grams	Combined mass of projector and electronics driver box

About Lumaxis

Lumaxis designs high-performance Projection Engines for manufacturers of 3D optical metrology solutions.

Lumaxis draws on the expertise of its parent company, NVIS, Inc., an ISO-9001:2015 registered manufacturer of high-resolution, near-eye and projection display systems designed for high-fidelity immersive training and simulation. Additionally, the close working relationship developed over the years with Forth Dimensionsion Displays (now sister companies,

as both are wholly owned subsidiaries of Kopin Corporation), the Spatial Light Modulator (SLM) supplier to multiple leading pioneers in 3D metrology markets, ensures that best practices are always maintained and competitive, cost effective, high value products are used in the design of its projection engines. Lumaxis's core strengths are its intimate familiarity with LCoS microdisplays, experience designing, producing and supporting compact projection assemblies, as well as its reliable, low risk and time efficient design cycles. For more, visit www.lumaxis.net.

Contact :-

Lumaxis

11495 Sunset Hills Rd.,

Ste. 106, Reston, VA 20190, USA

+1 (571) 201-8095
inquiries@lumaxis.net