DLP In industrial Applications
June, 2013

Enabling Breakthrough Applications in Consumer & Industrial
EKB is an Official Technology design house.

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Agenda

- **DLP Basics**
  - Technology Overview
  - DLP Markets and Applications
  - Consumer Front Projection Applications
  - Industrial Non-Display Applications

- **The Pico chips**
  - The Pico light engine
  - Light engines for embedded applications
  - Utilization examples

- **Development kits**
  - DLP Development tools
  - LightCrafter Series
  - Laser LightCrafter

- **3D Optical Measurement**
  - Structured Light Basic Operation
  - Structured Light Consideration
  - Structured Light Encoding
  - Setting up 3D scanner
  - Putting it all together

- **Discovery 4100 development kit**
  - D4100 types and basics

- **Q&A**
DLP Basics

Technology Overview
DLP Technology – DMD Device

- Micro-Devices in the micrometer scale
- Electro-integrating electrical circuits
- Mechanical- & mechanical elements (i.e. sensors, actuators, hinges)
- Systems into a common silicon substrate

- DLP = Digital Light Processing
- Array of micromirrors
- Type of Spatial Light Modulator (SLM)
- Invented, developed and owned by Texas Instruments
Does DLP fit your Application?

Does your system receive or transmit visible or invisible light?

- **Ultra-Violet Light** 320nm - 400nm
- **Visible Light** 400nm – 700nm
- **Infrared Light** 1100nm – 2000nm

Yes

Do you need to steer the light?

- **Digital Array ( +/- 12° angle)**

Display: Video & Imaging

DLP is a fit!
Evaluate with DLP D4100 or Pico Projector Development Kits
# DLP Features & Benefits

<table>
<thead>
<tr>
<th>DLP Features</th>
<th>Customer Benefits or Problem Solved</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Optical Throughput</td>
<td>Non-polarized light for easier optics design and higher optical efficiency (as compared to other technologies that lose more light)</td>
</tr>
<tr>
<td>Non-polarized light</td>
<td>------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Fast pixel switching speeds</td>
<td>Enables high bit depth for more detailed images and higher resolution features. High frame rates for fast image capture and pattern configurations.</td>
</tr>
<tr>
<td>up to 32,000 fps on select devices</td>
<td>------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Ultra-violet &amp; Infrared chips</td>
<td>One of few spatial light modulators commercially available that works with UVA and Near-IR light to enable light exposure and (sub)surface detection systems. UVA optimized for 365nm and NIR optimized for 1100-2000nm</td>
</tr>
<tr>
<td>Reliable</td>
<td>TI has shipped over 20 million devices and has proven market share with a stable supply chain. Operating temperatures of 0 – 70°C.</td>
</tr>
<tr>
<td>commercially available since 1996</td>
<td>------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Small LED Optical Engine Solutions</td>
<td>Enables significantly smaller light engine designs, more physically robust designs and an improved color gamut. As compared to lamps, offers improved lifetime and is “green” due to elimination of mercury.</td>
</tr>
<tr>
<td>Independent Pixel Control</td>
<td>Allows control of each micromirror independently to enable advanced spatial light modulation, such as light intensity control, wavelength selection, custom pattern generation and much more.</td>
</tr>
<tr>
<td>Capable of 100% Offset</td>
<td>Enables image views from a flat surface, such as a table, without the need for a tripod or complex optics.</td>
</tr>
</tbody>
</table>
DLP Technology – How it Works
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DLP Technology – How it Works
DLP Technology – Data Path

- User generates binary image data
- Data is loaded to the CMOS structure under the mirrors
- Mirrors are reset to update new image

Reset => Transfer electrical state to mechanical state of mirror
DMD Formats

0.95” 1080p
1920x1080 10.8 μm

0.7” XGA
1024x768 13.68 μm

0.55” XGA
1024x768 10.8 μm

0.3” DMD
WVGA 854x480 7.6 μm

0.45” DMD
(new) WXGA 854x480 7.6 μm
DLP Markets and Applications

Consumer Front Projection Applications
<table>
<thead>
<tr>
<th>Cell Phones</th>
<th>Camera/Camcorder</th>
<th>Pico Media Players</th>
<th>Gaming/Multimedia</th>
<th>Docks</th>
<th>Notebook Companion</th>
<th>Multimedia Pocket</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEAM “Android”</td>
<td>Camera</td>
<td>PK301</td>
<td>C20</td>
<td>Brightboxe (WVGA)</td>
<td>Optoma DV20</td>
<td>Notebook Projection Companion</td>
</tr>
<tr>
<td>SH-06C</td>
<td>Camcorder/Projector</td>
<td>SP-H03</td>
<td>PK101</td>
<td>GT-100</td>
<td>Optoma</td>
<td>HS200G</td>
</tr>
<tr>
<td>Phone Dock F-04B</td>
<td></td>
<td>V50</td>
<td>PK102 (Media Player)</td>
<td>Optoma</td>
<td>iEmmet</td>
<td>HX300G</td>
</tr>
<tr>
<td>W9600 Phone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Adayo</td>
<td>SP-P410M</td>
</tr>
<tr>
<td>eXpo™ Pico Projector Snap-on Accessory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.55 Not Pico</td>
<td>cinepic</td>
</tr>
<tr>
<td>ML130</td>
<td></td>
<td>ML580</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Announced**
- **Shipping**
DLP Markets and Applications

Industrial Applications
DLP Applications

DLP Technology is well known for consumer display...

Front Projection  Cinema  TV  Pico Projection

The Digital Micromirror Device can enable much more...

Industrial Exposure  Medical Imaging  Spectroscopy / Optical Networking  3D Optical Measurement
Digital Light Exposure

1. Light Source

2. Digital Pattern

3. Photosensitive Material
Digital Exposure Markets

PCB Lithography

FPD Lithography

3D Printing

Industrial End Equipment

DLP Advantages
- UV capable
- pixel/feature size
- speed

Enabling Growth Markets

Radial pattern
L=15μm
Digital Exposure Systems – DLP Value

- **Compatible with wide range of light spectrum**
  - Wavelength from Mercury lamp: 248nm-405nm
  - Organic compounds in LCD panels are susceptible to high heat and light energy stress

- **Fast frame rate allows finer resolution to sub 50um line-width**
Wavelength Control Using DLP

1. Light spectrum spread across DMD array
2. Turn on rows to select wavelength, columns to select intensity
Wavelength Control

λ Spectrum on the Input Fiber

λ Spots Incident Upon the DMD and the Associated DMD Mirror Patterns

λ Spectrum on the Output Fiber
DLP® Technology for Spectroscopy
2. Programmable control of spatial mirror array

3. Sample analysis (absorption / emission)

1. Optics for light dispersion

Example System Block Diagram
Wavelength Control Apps

Spectrometers

- Pharmaceutical
- Materials
- Air quality

Optical Networking

- Oil & Gas
- Safety
- Water quality

ROADMs
Reconfigurable Optical Add-Drop Multiplexer

WSS
Wavelength Selective Switch

VOA
Variable Optical Attenuator
Spectroscopy – DLP Value

- **High resolution**
  - High accuracy in measurement – more pixels -> more data
  - Large optical throughput (1080p, WUXGA)

- **Fast switching speed**
  - Faster time (~32kfps switching rate) enables real-time measurement

- **Full spectrum of light**
  - Broader applications involving IR and UV (248nm-2500nm)
Medical & Life Sciences Applications

Maskless Array Synthesizer (MAS) Technology

Vascular Imaging

3D Dental Imaging

Hyperspectral Imaging

Microscopes
- confocal imaging
- 3D imaging

Surgical Lights

Phototherapy
Measuring and Sensing

Security

Industrial

Medical

Anywhere volumetric data is needed
DMD PICO Chips
What is DLP Pico™?

- DLP Chip = array of mirrors (0.25M to >1M)
- Each mirror ~1/10th human hair
- DLP + Optics + Illumination = stunning picture
Broad Portfolio
“A Solution For Every Application”

New 0.45” HD (WXGA)

0.3” WVGA

0.24” VGA

0.2” nHD
Pico Light Engine

Light sources entrance
Dichoric Mirrors R,G,B
Condenser
DMD
Mirror
Projection Lens
Pico Light Engine

9.98mm
7.15mm
16.3mm
18mm
8.8mm
DLP3000

FEATURES
- 0.3-Inch (7.62 mm) Diagonal Micromirror Array
  - 608 x 684 Array of Aluminum, Micrometer-Sized Mirrors
  - 7.6-μm Micromirror Pitch
  - ±12° Micromirror Tilt Angle (Relative to Flat State)
  - Side Illumination for Optimized Efficiency
  - 3-μs Micromirror Cross Over Time
- Highly Efficient in Visible Light (420 nm–700 nm):
  - Window Transmission 97% (Single Pass, Through Two Window Surfaces)
  - Micromirror Reflectivity 88%
  - Array Diffraction Efficiency 86%
  - Array Fill Factor 92%
  - Polarization Independent
- Up to WVGA Resolution (854x480) Wide Aspect Ratio Display
- LowPower Consumption, only 200 mW (Typical)
- 15-Bit, Double Data Rate (DDR) Input Data Bus
- 60-MHz to 80-MHz Input Data Clock Rate
- Integrated Micromirror Driver Circuitry
- Supports –10 °C to 70 °C
- 16.6-mm by 7-mm by 5-mm Package Footprint
- Dedicated DLPC300 Controller for Reliable Operation
- Package Mates to PANASONIC AXT550224 Socket

APPLICATIONS
- Machine Vision
- Industrial Inspection
- 3D Scanning
- 3D Optical Metrology
- Automated Fingerprint Identification
- Face Recognition
- Augmented Reality
- Embedded Display
- Interactive Display
- Information Overlay
- Spectroscopy
- Chemical Analyzers
- Medical Instruments
- Photo-Stimulation
- Virtual Gauges
Engines for embedded applications (RGB, IR, UV)

IPK-T0063
Resolution: VGA
RGB ver: 30lm

Engine: IPK-10058
Resolution: WVGA
RGB ver: 80-100lm
IR ver: 1W-3W
(808nm/980nm)

EPK-W002S2/UV
Resolution: WXGA
RGB ver: Up to 350lm
UV ver: 1.5W / 3W @ 405nm
UVIR ver: Coming soon.
Unique HUD utilization using embedded UV engine
3D Printer using embedded light engine

<table>
<thead>
<tr>
<th>System</th>
<th>DLP 0.3” DMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Source</td>
<td>LED 405nm</td>
</tr>
<tr>
<td>Light Engine Output</td>
<td>15mW</td>
</tr>
<tr>
<td>X/Y Resolution</td>
<td>450ppi (56 micron)</td>
</tr>
<tr>
<td>Z-Axis (single Layer Thickness)</td>
<td>0.05mm (50 micron)</td>
</tr>
<tr>
<td></td>
<td>Hardware can support up to 0.005mm (5 micron)</td>
</tr>
<tr>
<td>Build Speed</td>
<td>3cm per hour @ Z-Axis 100 micron</td>
</tr>
<tr>
<td></td>
<td>2cm per hour @ Z-Axis 50 micron</td>
</tr>
<tr>
<td>Build Size (Footprint)</td>
<td>43mm x 27mm x 180mm</td>
</tr>
<tr>
<td>Full Kit Dimensions</td>
<td>20.5cm (W) x 20.8 (L) 33.5cm (H)</td>
</tr>
</tbody>
</table>
DLP Development Tools

- **Light Crafter**
  - Resolution: Low
  - Cost: 20-30lm

- **HB - Light Crafter**
  - Resolution: Low
  - Cost: 80-100lm

- **Laser Light Crafter**
  - Resolution: HD
  - Cost: 80-100lm

- **Discovery 4100**
  - Expert's DLP Expertise
  - Features:
    - UV and Exposure
    - Optical Networking
    - Hyperspectral Imaging

**50lm (GREEN and BLUE) + IR Laser 1W/3W**

0.3” DMD WVGA
LightCrafter Development Kit Series

LightCrafter / HB-LightCrafter / Laser LightCrafter

• DMD controller board
• Processor and interface board
• High Power light source driver board (in HB and Laser LightCrafter)
• Embedded Linux OS
• High speed patterns using the native DLP3000 resolution (608 x 684)
• Up to 4000 Hz binary pattern rate
• Up to 120 Hz 8-bit grayscale pattern rate
• Display images or video up to WVGA resolution (854 x 480)
• Configurable I/O trigger for synchronizing with cameras, sensors, etc
• DM365 embedded processor running embedded Linux
• 128MB NAND flash memory for pattern and sequence storage
• USB, Mini HDMI, UART interfaces
• USB-based API and host GUI

Designed for Structured Light applications
### Laser LightCrafter

<table>
<thead>
<tr>
<th>System</th>
<th>DLP 0.3&quot; DMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native Resolution</td>
<td>WVGA (854 x 480)</td>
</tr>
<tr>
<td>Brightness</td>
<td>20/50 Lumens</td>
</tr>
<tr>
<td>Contrast Ratio</td>
<td>1000:1</td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td>16:9 Native</td>
</tr>
<tr>
<td>Light Source</td>
<td>2LED (GB)+ Laser 808nm 1W/3W</td>
</tr>
<tr>
<td>LED Light Life</td>
<td>20000 Hours</td>
</tr>
<tr>
<td>LED Power</td>
<td>14W</td>
</tr>
<tr>
<td>Throw Ratio</td>
<td>1.85 at 100% Offset</td>
</tr>
<tr>
<td>Image Size (m)</td>
<td><a href="mailto:0.4m@0.217m">0.4m@0.217m</a>; <a href="mailto:4m@2.2m">4m@2.2m</a></td>
</tr>
<tr>
<td>Image Size (inch)</td>
<td><a href="mailto:1.32ft@9.5inch">1.32ft@9.5inch</a>; 13ft@96inch</td>
</tr>
<tr>
<td>Focus Mechanism</td>
<td>Manual</td>
</tr>
<tr>
<td>Dimension</td>
<td>74.6 x 60 x 18.5mm (Include heatsink)</td>
</tr>
<tr>
<td>Size</td>
<td>82cc</td>
</tr>
</tbody>
</table>

![Laser LightCrafter Diagram](image-url)
Questions
3D Optical Measurement

Technical Background
Optical 3D Measurement Systems

- Use triangulation (geometry) to determine the depth of an object

Stereo Triangulation

Single Line Scan

Structured Light
3D Optical Measurement

Structured Light – Basic Operation

1. DLP programs light patterns

2. Object distorts light

3. Camera or Sensor detects light distortion

4. Image processing
   Using triangulation algorithms
Structured Light – Basic Operation

- Calibration Routine (one-time step for most systems)
  - Project Structured Light Patterns
  - Camera Trigger/Image Capture
    - Camera-Projector Pixel Correspondence (decode patterns)
      - Triangulation (depth calculation)
        - Point Cloud and Surface Reconstruction (3D rendering)
          - Measurements
          - Object Recognition/Comparison
Structured Light – Considerations

- Pattern Generator and Camera Specifications
  - Resolution
  - Frame speed
  - Lenses
  - Light Source

- System Calibration

- Choice of Patterns / Encoding

- Image Processing and 3D Rendering
Structured Light – Encoding

Pattern 1

Pattern 2

Pattern 3

(101...)
Setting Up a 3D Scanner

- **Create new project**
  - Upload binary patterns
  - Set frame speed
  - Set output sync signal

- **Connect LightCrafter to camera**

- **Project binary patterns and capture images**
Project Structured Light Patterns
Project Structured Light Patterns
Setting Up a 3D Scanner

- **Image Processing**
  - Arrange captured images
  - Analyze pattern distortion / triangulation
  - Visualize Data

- **Generate Point Cloud**

- **Create 3D Model**
Build Point Cloud

Image generated with MeshLab, a tool developed with the support of the 3D-Coform consortium
Render Object in 3D

Image generated with MeshLab, a tool developed with the support of the 3D-Coform consortium
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Image generated with MeshLab, a tool developed with the support of the 3D-Coform consortium
Putting It All Together

Structured Light Demo
Putting It All Together

Structured Light Demo

- Live View
- Set Reference
- Take Measurement
- Reset Camera
- Export Data
- Change Contrast Threshold

[Image of the DLP Structured Light Demo interface]
Putting It All Together

Color Scale: Different color represent different distances across Z axis
Putting It All Together
Putting It All Together
Putting It All Together
Putting It All Together
Putting It All Together
Questions
The Discovery 4100 Kit

- For professional users
### DLP D/W4100 Developer Kit

**DLPD4X00KIT**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Three DMD offerings</strong></td>
<td>XGA (1024 x 768) and 1080p (1920 x 1080) resolutions</td>
</tr>
<tr>
<td></td>
<td>- High resolution chipsets and 2 package types enabling high accuracy</td>
</tr>
<tr>
<td></td>
<td>equipment and multiple design options.</td>
</tr>
<tr>
<td><strong>Three window options</strong></td>
<td>includes windows optimized for Visible, UVA and Near-IR light</td>
</tr>
<tr>
<td></td>
<td>- UV enables light exposure systems such as lithography &amp; 2D/3D print</td>
</tr>
<tr>
<td></td>
<td>systems optimized around 365nm.</td>
</tr>
<tr>
<td></td>
<td>- NIR enables (sub)surface detection for measurement &amp; imaging in the</td>
</tr>
<tr>
<td></td>
<td>range of 1100-2000nm.</td>
</tr>
<tr>
<td><strong>Clock Rate of 400MHz (2xLVDS)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Data Rates up to 48.0 Gb/sec</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Maximum of 32,552 binary frames per second</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Very fast data transfer rates and pixel switching speeds.</td>
</tr>
<tr>
<td></td>
<td>- Enables high frame rates for</td>
</tr>
<tr>
<td></td>
<td>- fast imaging &amp; capture rates</td>
</tr>
<tr>
<td></td>
<td>- high bit depth for better image details/resolution</td>
</tr>
<tr>
<td><strong>Flex cable connection to remote DMD boards</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Offers easy optical and mechanical mounting</td>
</tr>
</tbody>
</table>

### D4100 DMD offerings

<table>
<thead>
<tr>
<th>Array Size</th>
<th>.95&quot; 1080</th>
<th>.7&quot; XGA</th>
<th>.55&quot; XGA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920x1080</td>
<td>1024x768</td>
<td>1024x768</td>
<td></td>
</tr>
<tr>
<td>Maximum Binary Patterns/Second</td>
<td>23,148</td>
<td>32,552</td>
<td>32,552</td>
</tr>
<tr>
<td>Data Rate (Gb/s)</td>
<td>48</td>
<td>25.6</td>
<td>25.6</td>
</tr>
<tr>
<td>Mirror Pitch (μm)</td>
<td>10.8</td>
<td>13.6</td>
<td>10.8</td>
</tr>
<tr>
<td>Window Options</td>
<td>VIS, UV</td>
<td>VIS, UV, NIR</td>
<td>VIS</td>
</tr>
</tbody>
</table>
D4100 for professional users

DLP® Discovery 4100
.55” XGA Type X Starter Kit
Maximum Wavelength range

Stretching performance

Window Anti-Reflective (AR) Coating Options

Stretching performance

Percent Transmission

Wavelength

NIR

Visible

UV

320
Questions
The same core technology that brought you DLP Cinema® can now be experienced from the palm of your hand.