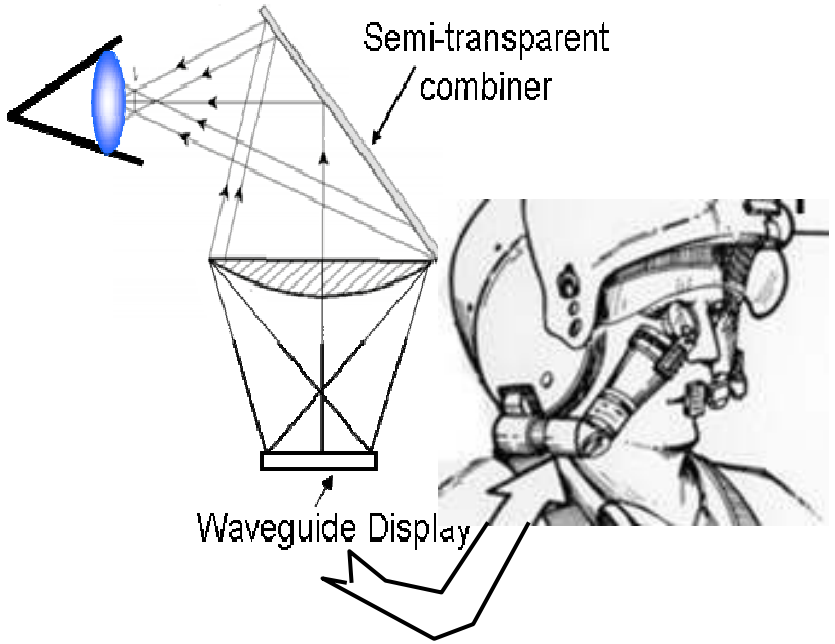
Waveguide Display
Applications and Requirements

- Image source for Helmet, Head, or Glasses Mounted Displays
  - Includes both military and commercial applications
- Eyepiece displays for digital cameras and video recorders
- Image source for structured light 3D applications
- Projection displays for home movies, television, business presentations
- Projection displays for flying and driving simulators

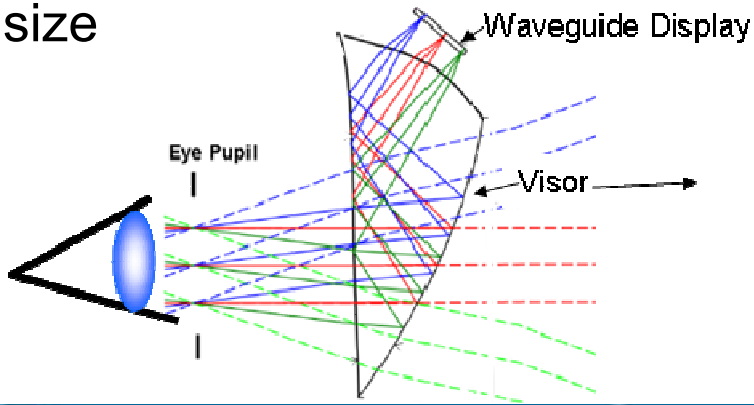
Application: Military Helmet Mounted Displays Require:

- High Resolution to display sensor imagery
- High luminance for daylight operation through semi-transparent optical combiners
- Large dynamic range to present symbology against natural scenes day and night
- High reliability
- 60 Hertz progressive operation
- 4 millisecond or less dwell time while providing daylight luminance
- Small size and minimal weight



Application: Commercial Simulation Displays Require:

- HDMI or 4K video resolution
- High reliability
- Short dwells to provide smooth motion video
- Affordable fabrication costs
- Minimal weight and small size



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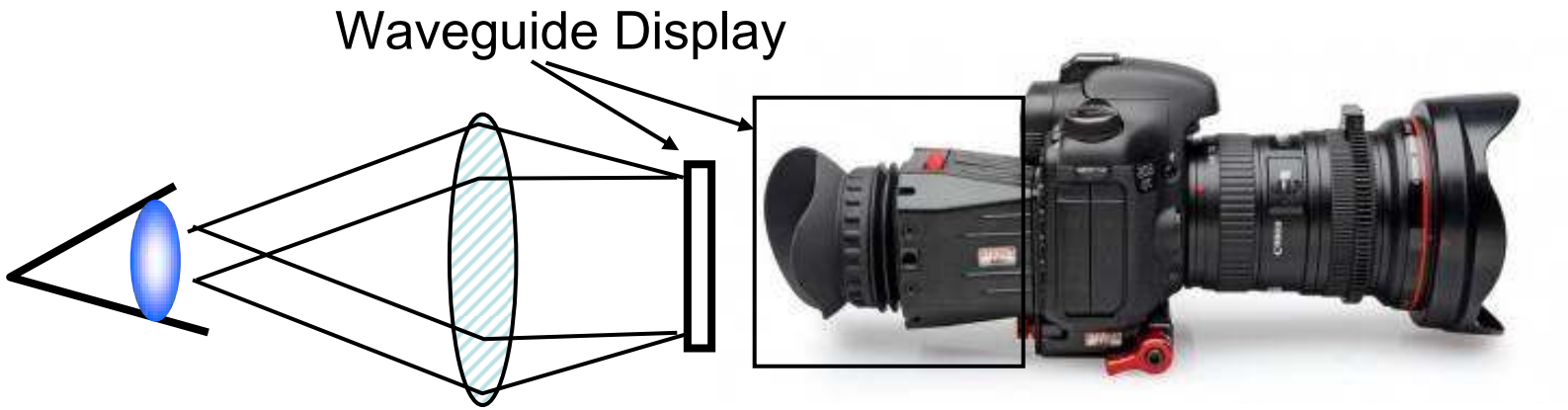
Application: Digital Camera Displays Require:

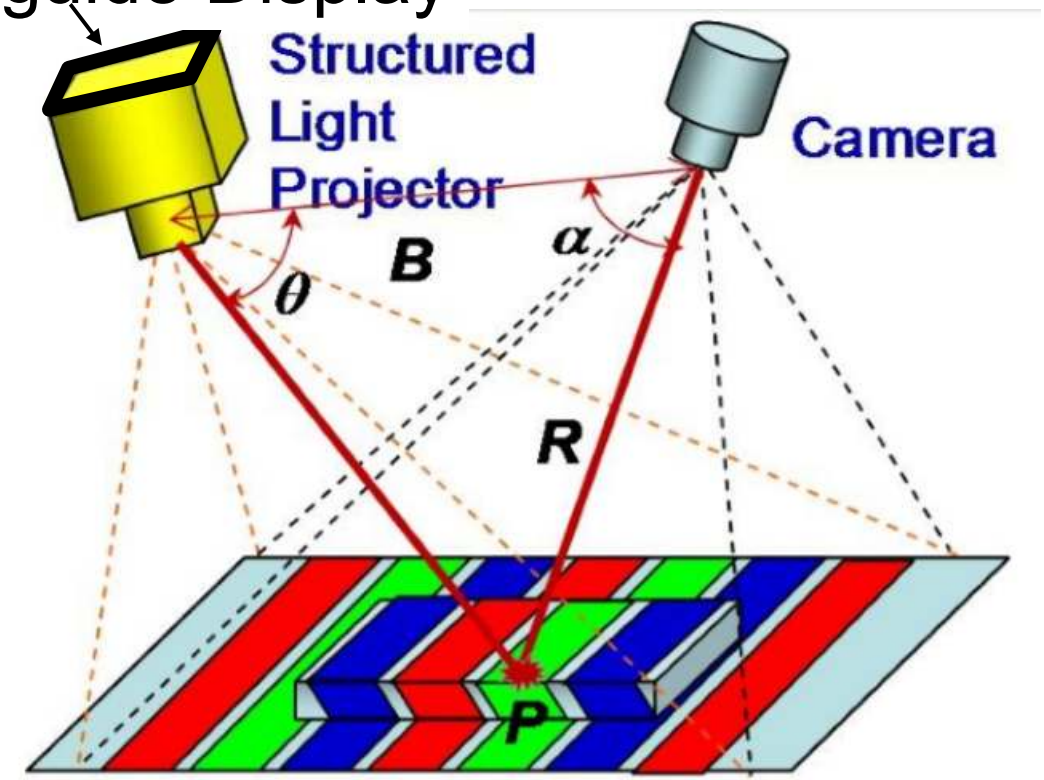
- High resolution
- High reliability
- Affordable fabrication costs
- Minimal weight and small size
- Moderate or minimal power and low voltage



Structured Light 3D Illuminators Require:

- High resolution
- High Luminance
- High speed

Waveguide Display



Projection displays for home movies, <u>television, business presentation</u>

- Examples of video projection
  - At left, home theater projector is behind the screen
  - At right, screen-less projector is mounted under the cabinet
  - The waveguide display has the resolution for a home theater and the size, simplicity, and affordable cost appropriate for a screen-less application.

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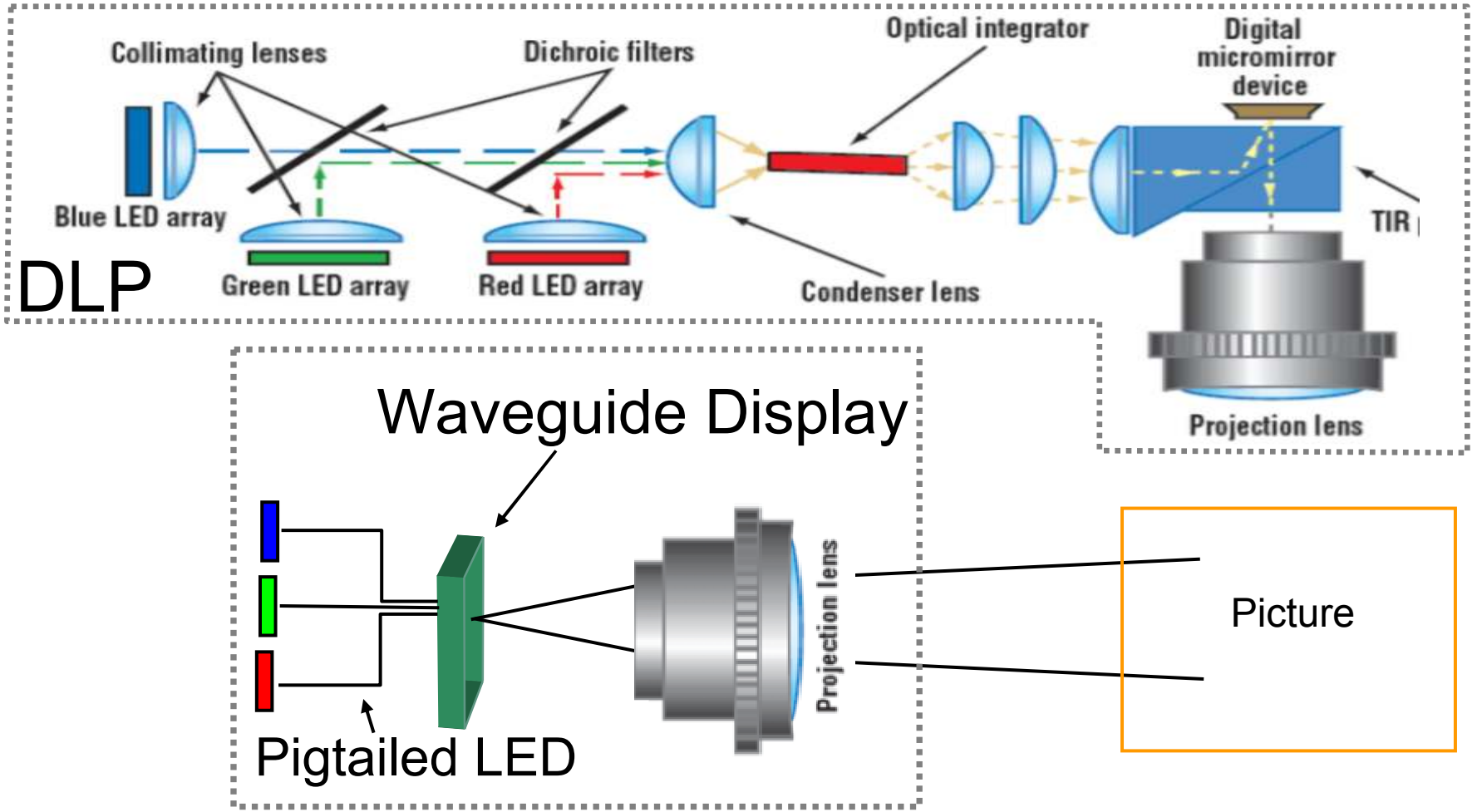
Projection displays for home movies, <u>television, business presentation</u>

- This slide compares Texas Instruments digital light processing (DLP) projector to a waveguide display projector
- The waveguide display projector is simpler and 1,000 times faster



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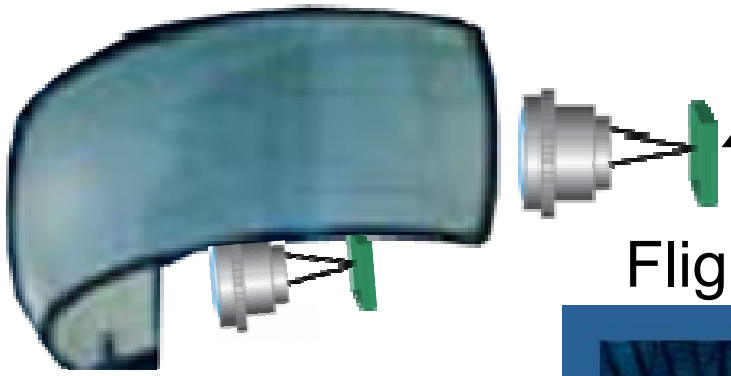
Projection displays for home movies, television, business presentation require

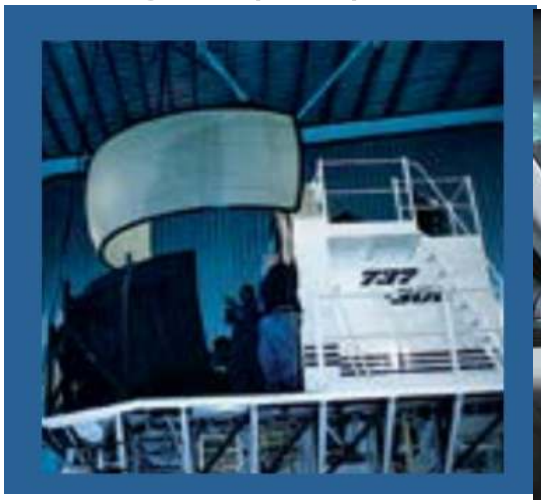
- Good color gamut
- High luminance
- HDMI and 4K compatible
- Display array and projector costs competitive with commercial alternatives like LCD and digital light processing (DLP) technology
- High reliability
- Speed that meets or exceeds LCD and DLP

Flying and Driving Simulators Require:

- High resolution
- Good color gamut
- High speed for motion video
- Affordable image array and projector costs



Flight (left) and driving (right) simulators



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Waveguide Display Characteristics

- The waveguide display is fabricated in CMOS using known processes available in any silicon foundry
- Array sizes are small and therefore affordable and easy to integrate into projectors
  - The table provides examples for various standard resolutions

Video Format	Number of Pixels	Size in Inches
Standard Video	640 by 480	0.13 by 0.10
HDMI	1920 by 1080	0.38 by 0.22
4K	3840 by 2160	0.8 by 0.43

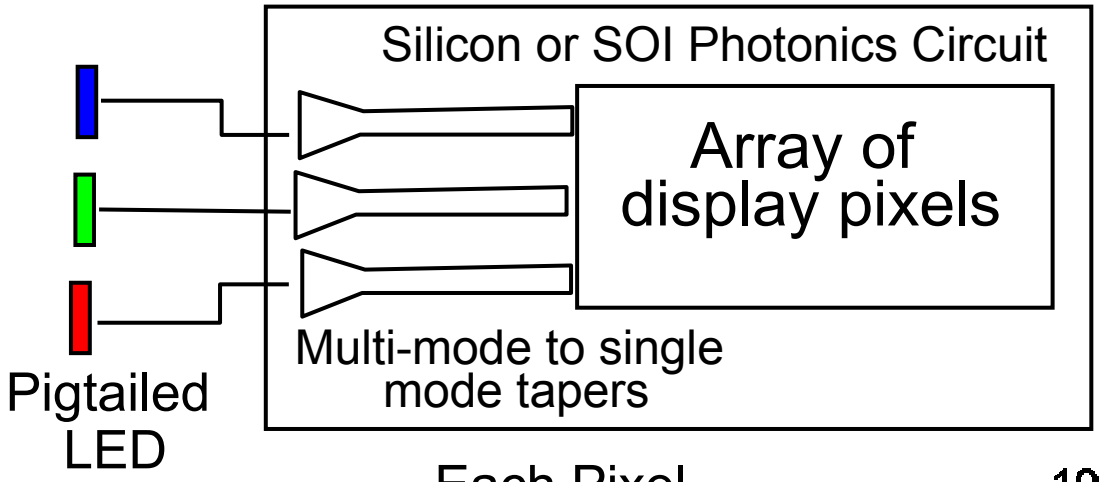
- Additional silicon is needed for addressing and other support electronics and waveguide wedges to couple in LED light

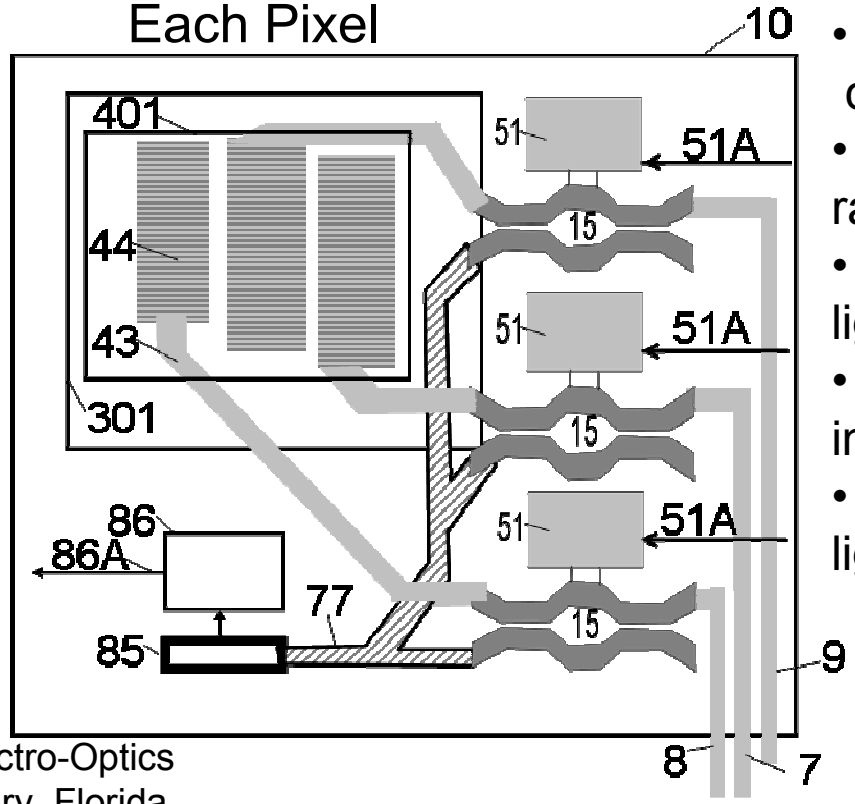
The silicon used for a 4k display is less than a square inch and therefore readily producible by today's standards

Waveguide Display Characteristics

- CMOS fabrication and small display size results in affordable cost and flexible production options
- In addition, the waveguide display has:
  - High luminance provided by off-array LED
  - Fast switching speeds
  - Low power and CMOS voltages
  - Exceptional uniformity
  - Full color gamut
  - High dynamic range provided by combining optical switching with time multiplexing of the LED
- In summary, the waveguide display
  - Provides bright, true color, high luminance, wide dynamic range, and high resolution imagery
  - In an affordable, small, and low power package
  - Using known CMOS processes available in any silicon foundry

Waveguide Display Fabrication





Each pixel (10) to left below:

- 7,8,9 waveguides distribute light
- 15 are Mach Zehnder (MZ) optical switches
- 51 are current mirrors that control MZ on state
- 44 are Bragg Gratings that radiate light
- 86 is a photo diode to monitor light that is not sent to radiators
- 401 are Bragg reflectors to increase efficiency
- 301 metallization blocks stray light

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Summary

- The waveguide display is fabricated using known CMOS processes available at any silicon foundry
- The pixels consist of Bragg Grating radiators, Mach Zehnder used as optical switches, and a silicon photo diode to maintain uniformity
  - The CMOS fabrication processes are well-known in the industry
- The waveguide display provides bright, high resolution imagery from a small silicon chip
- The combination of unsurpassed performance, small size and weight, inexpensive fabrication, and simple projector optics makes the waveguide display the technology of choice for many applications.