SID

Waveguide Optics
for
All Day Wearable Displays

Evolution

Ph.D. - 1986

Ph.D. – Stereo Shutter, Acoustic 3D Tracked, VR

Virtuality - 1993

Virtuality CS1000 – Public Virtual Reality Pod
40DFOV

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Virtuality - 1995

Virtuality CS2000 – Multi-Player 43DFOV

Virtual Gloves Haptic feedback - $60k

Virtuality / Atari – Consumer VR System – 1997/1999

Consumer, IR Optical Tracking, 40DFOV
$499, Single Panel Duel Lens

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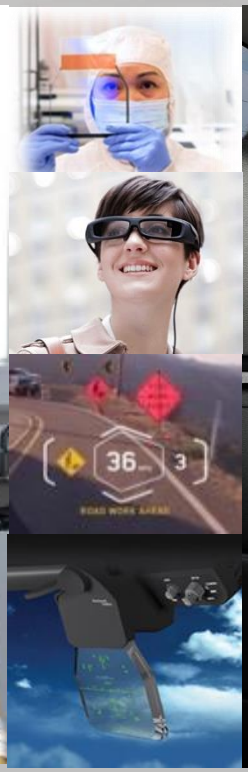
All Day Wearable Displays

What We Do



Innovative Augmented Reality Display and Sensor Solutions for OEM's

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DigiLens Inc.- Technology and Services

Design Tools

Optical Materials

Sample / Manufacturing

Manufacturing Tools

PRODUCT	***PROPRIETARY NANOCOMPOSITE MATERIALS*** *(70+ patents)*
CO-DEVELOPMENT	**HEAD-UP DISPLAYS** · **HELMET-MOUNTED DISPLAYS** · **EYE-GLASS DISPLAYS**
END MARKETS	AREOSPACE · AUTOMOTIVE · MILITARY / AREOSPACE · ENTERPRISE · MILITARY / CONSUMER · ENTERPRISE · MILITARY
BUSINESS MODEL	**CO-DEVELOPMENT ($ *NRE*)** → **TECHNOLOGY LICENSE ($ *ROYALTIES*)** → **NANOMATERIAL SALES *($ VOLUME)***

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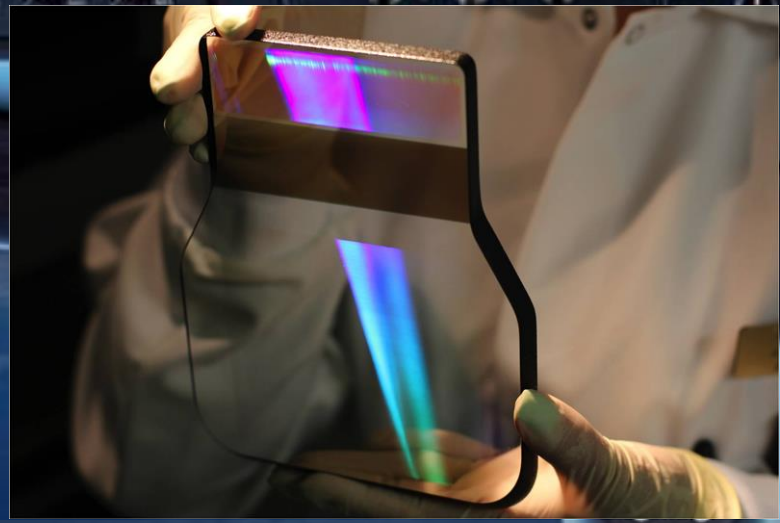
DigiLens AeroHUD – First Waveguide HUD in Commercial Service - FAA Certified.

AEROSPACE
MANUFACTURING and DESIGN



Embraer HUD, EVS certified for Legacy 450, 500
Head-Up Display and Enhanced Vision System awarded FAA/EASA/ANAC certification for Legacy 450 and Legacy 500. October 12th, 2016

Digilens HUD - breaks “FOV and Size LIMITATIONS –

4x Larger AR - HUD

”Continental Speeds up Evolution of AR Head-up Displays through Strategic Partnership with DigiLens”

Continental

Helmet and Eyeglass Display Drivers – *Productivity, Communications and Safety*

HMD Types	Platform	Frequency of Use	Task Complexity	Field of View	Oculars	3D Sensing / 3D Display	Eye Tracking
Monocular	Eyeglasses, Helmets & Hardhats	Occasional to All Day	Simple	Small / Medium	Monocular	No	No
Binocular		Occasional	Simple to Moderate	Medium / Wide	Binocular		
Binocular + 3D			Moderate to Complex			Yes	Yes

Monocular Data/Video Viewer

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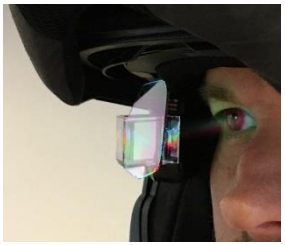
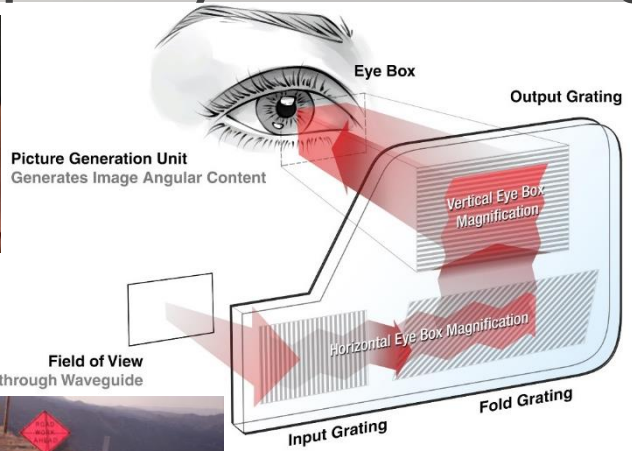
Binocular, Wide FOV, 3DOF Tracked, Data/Video Viewer Interactive

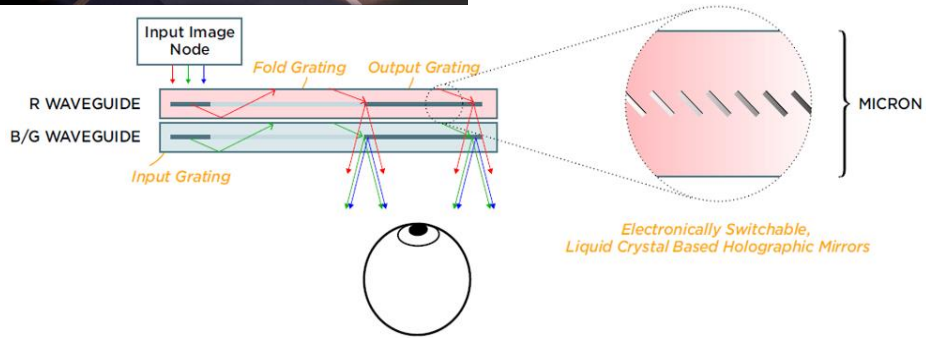
Binocular, 3D, Wide FOV, 6DOF Tracked, Variable Depth of Focus, Foveated Imaging, Data/Video/VR Interactive

Waveguide Technology

DigiLens Optical System in a Waveguide

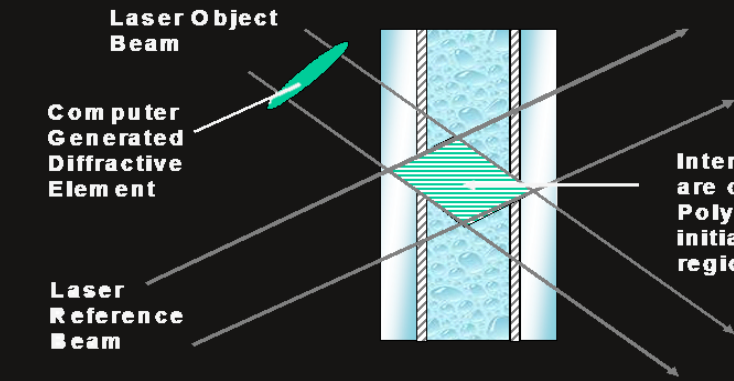






- Based on proprietary liquid crystal based nanomaterial.
- Nanoscale diffractive patterns are selectively laser scanned into a waveguide display eyepiece using a proprietary process.
- Many optical functions (IP Cores) can be integrated in thin layers.
- The exposed diffractive patterns, act like transparent mirrors, performing optical functions such as redirecting, input/output light or magnifying the tiny image from a microdisplay chip.
- DigiLens waveguides are also switchable, allowing a full color image to be selectively guided, avoiding color smearing.
- The diffractive patterns are optically printed (not etched):
  - Optical advantage: 100% efficiency and a wider FOV.
  - Manufacturing advantage: lower volume costs.

Principles of Switchable Bragg Gratings

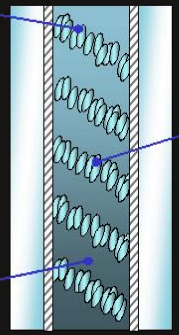


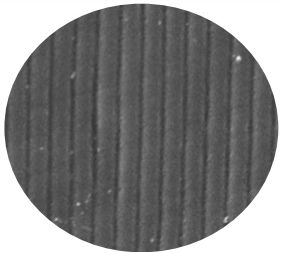
Interference fringes are created; Polymerization is initiated in bright regions.

LC-rich regions with refractive index n_{LC}

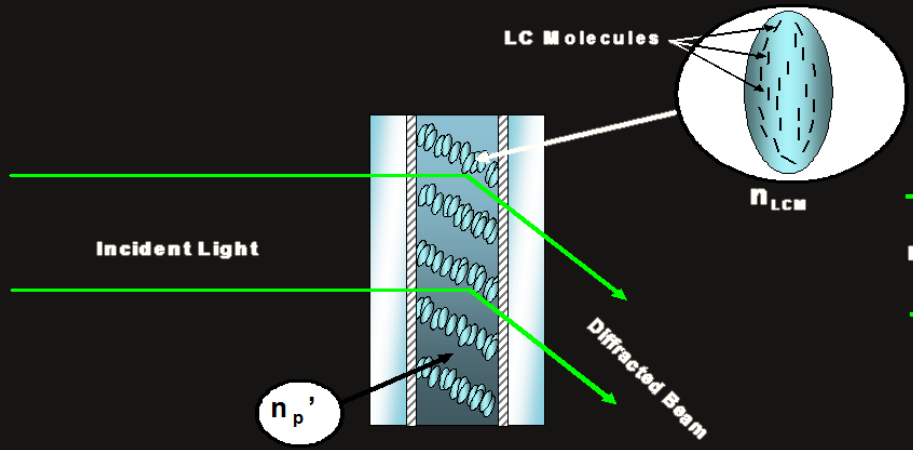
Polymerization forms alternating planes that are either rich in polymer or LC having different average refractive indices

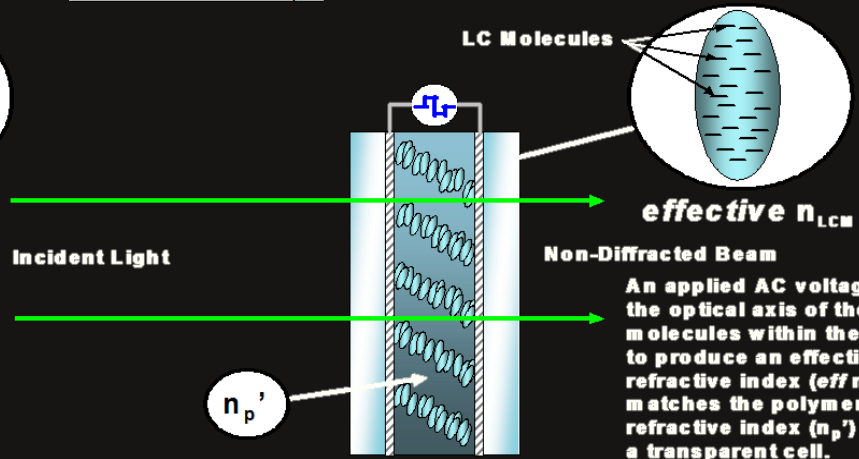
Polymer-rich regions with refractive index n_p





SEM of a Switchable Bragg Grating

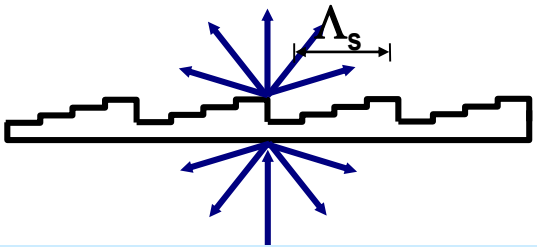




An applied AC voltage orients the optical axis of the LC molecules within the droplets to produce an effective refractive index (*eff* n_{LCM}) that matches the polymer refractive index (n_p') creating a transparent cell.

Bragg Gratings Vs. Surface Relief : Fundamental Advantages

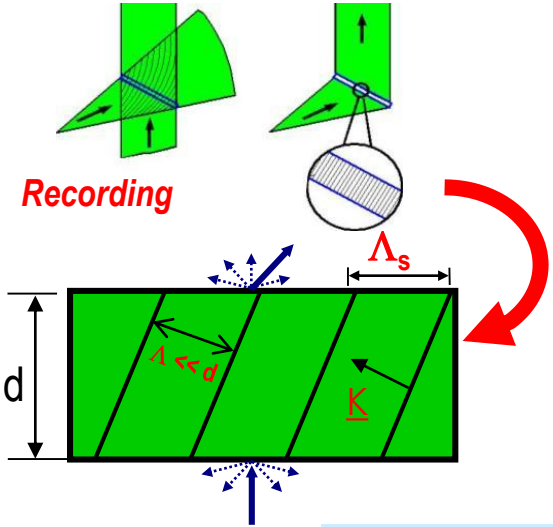
Surface Relief Gratings

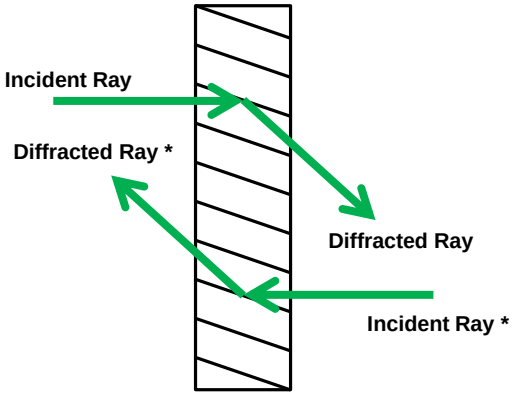


Surface Relief Gratings limited by-

- Grating physics.
- Ability to optically isolate layers.
- Higher orders and dispersion.

DigiLens "Switchable Bragg Gratings"





Reciprocity

- **Diffraction Angle - same for all gratings – as determined by Λ_s**
- **Key variables: index modulation, thickness, k-vector (K)**
- **Model using Kogelnik theory (with modifications for birefringence).**
- **Modelling DigiLens waveguides is a 3D task – DigiLens Tools Enable**

RECIPROCITY

- Diffraction gratings are two way reciprocal devices.
- 99% efficient = Wide FOV and Low Power for mobile
- Reciprocal paths are both 'On Bragg' – so supported
- Reciprocal paths ensure stray light is not generated.

DigiLens Optical System in a Waveguide – for Helmet or Eyeglasses

Waveguide Display

- 3mm Glass/Plastic Optic
- Low Cost Copy from Master

Custom Printed Patterns

- Lenses, filters, prisms, pupil expansion
- Switching enables RGB color

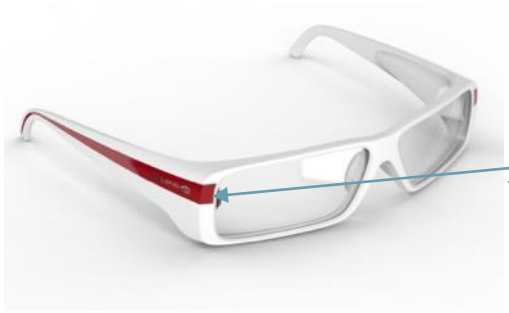
Waveguide Optic

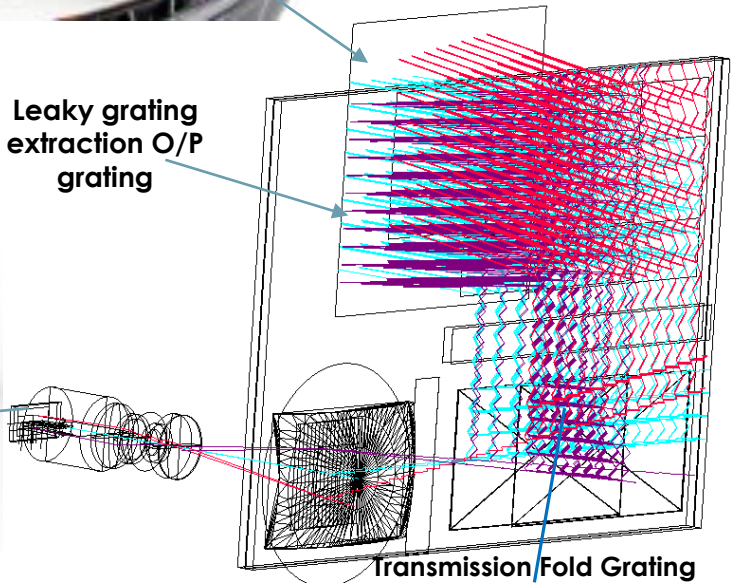
- 92% Transparent
- Eliminates IPD Adjustment

Extra Large 25x25mm eye box.

Pico Projector Mounted in Helmet or Glasses Rim

Leaky grating extraction O/P grating





Transmission Fold Grating [Single Layer per Waveguide]

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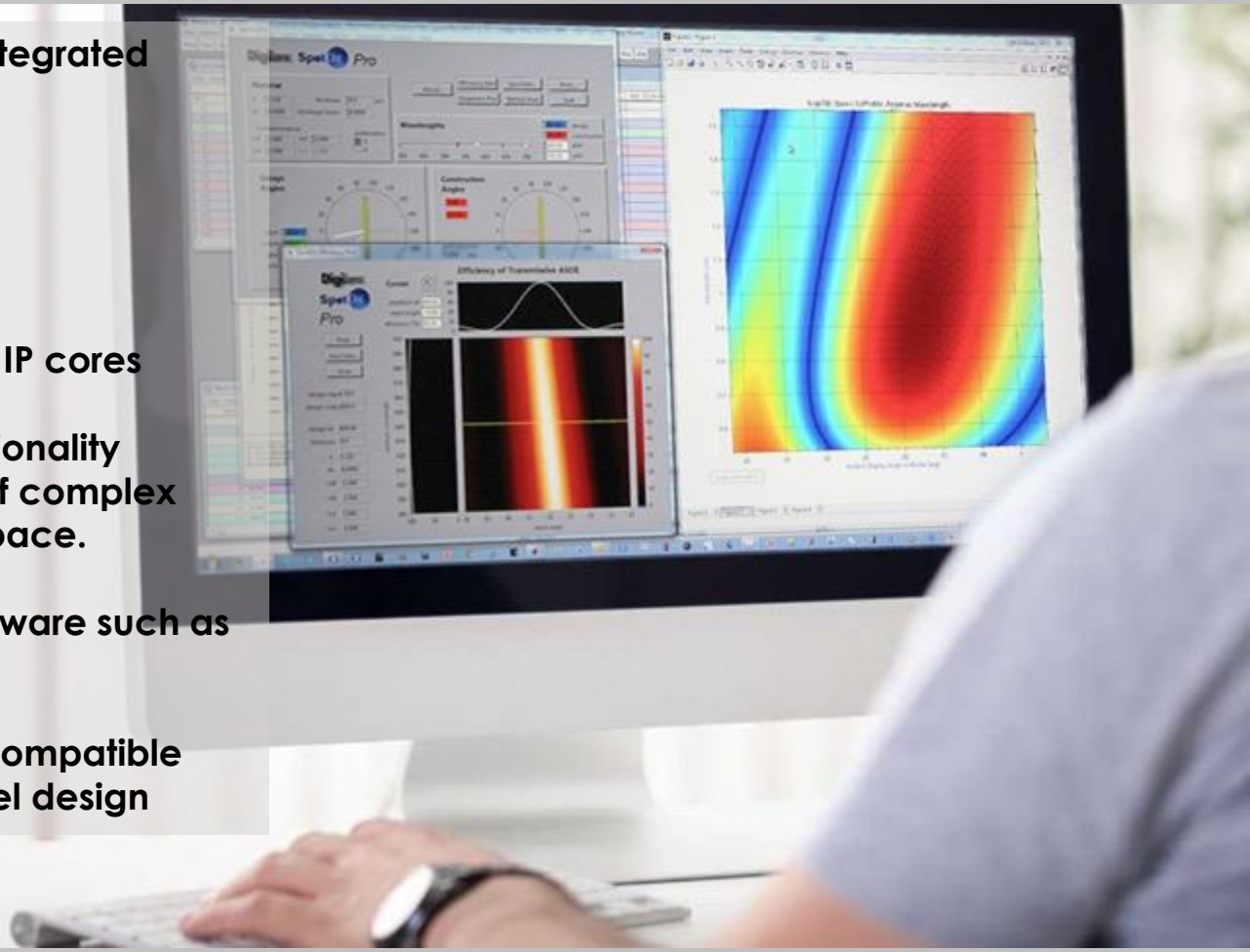
Optical Design Tools

- DigiLens® CAD tools - Design integrated optical waveguide devices
- Support / Training
- Application / Mastering design
- Conceiving / Adapting Optical IP cores
- Economy of form factor & functionality comes from the manipulation of complex wave-guided ray paths in 3D space.
- Major challenge for current software such as ZEMAX, CODEV etc.
- Developing custom tools now compatible with ZEMAX for full optical model design



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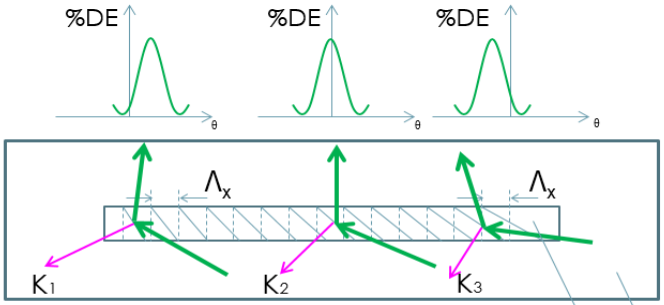
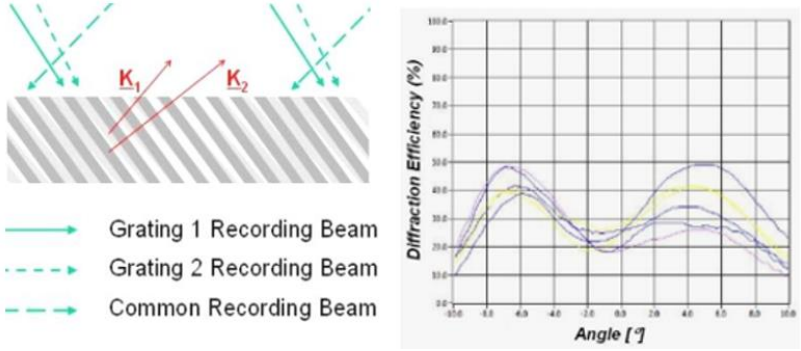
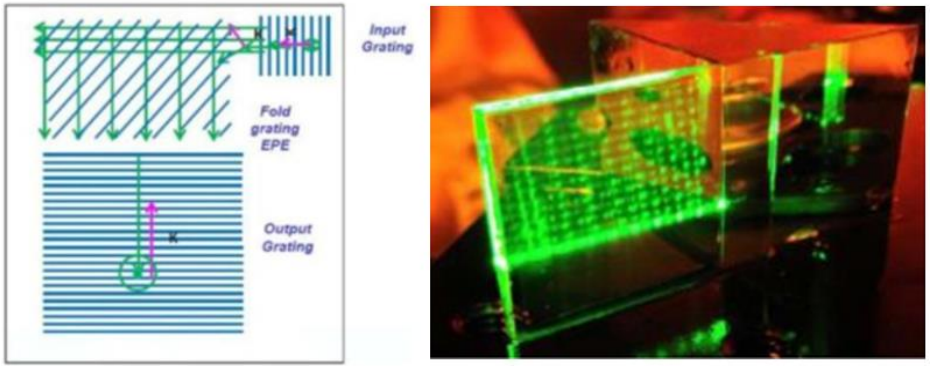
Key IP Cores for AR Displays



Rolled K-Vector Gratings



Multiplexed Gratings



Fold Gratings

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MonoHUD – Wearable

VR Training and Simulation - 1998

Kawasaki – Motorcycle Simulator

DigiLens MotoHUD™ AR Motorcycle Helmet "Reference Design"

"BMW made a motorcycle helmet that builds in the best parts of Google G
The VERGE, Jacob Kastrenakes, January 9, 2016

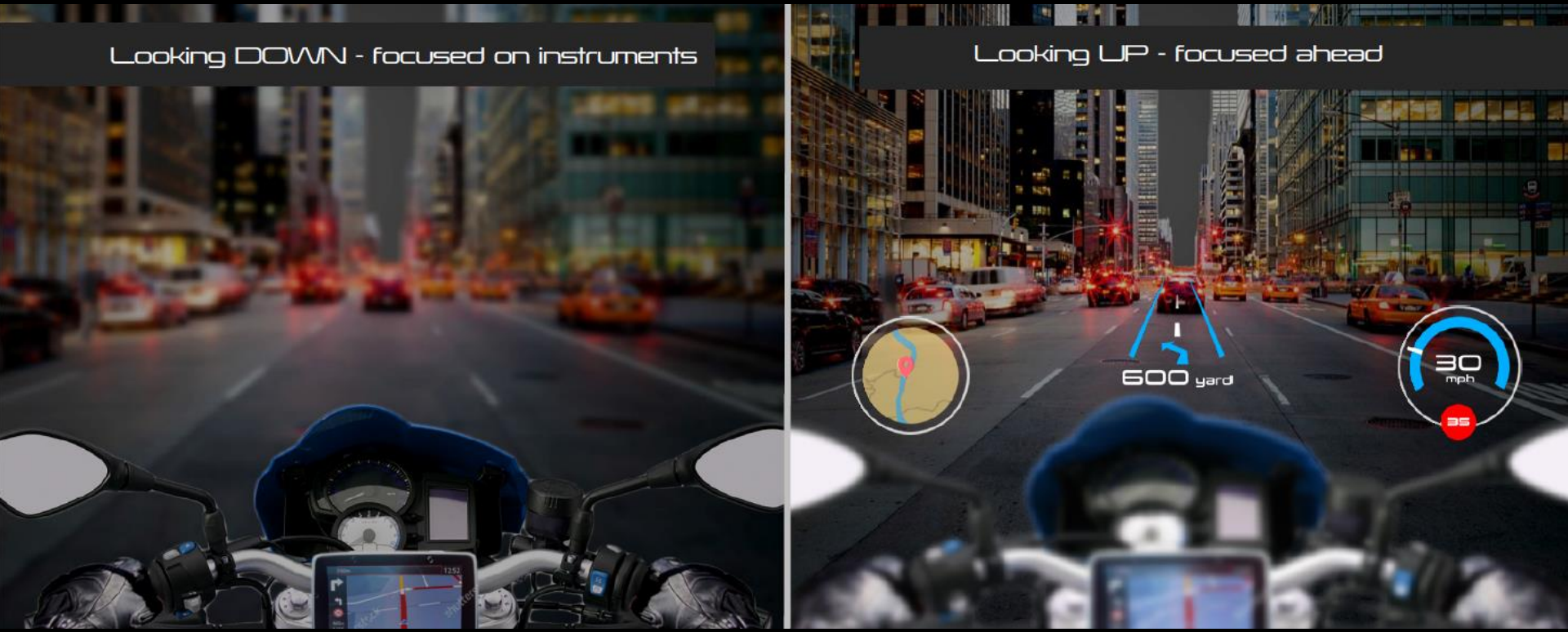
"BMW HUD Helmet Uses Top-Notc.. DigiLens Technology"
Autoevolution, Florin Tibu, January 7, 2016

"BMW Just Debuted a Sci-Fi Motorcycle Helmet"
***Fortune**, John Gaudiosi, January 7, 2016*

"DigiLens helmet adds augmented reality view for motorcyclists"
***Mashable**, Adario Strange, January 6, 2016*

"More Details On BMW's Motorcycle Helmet HUD"
Motorcycle.com, Dennis Chung, January 6, 2016

Why are AR HUDs Safer?



MonoHUD Specification

Design Parameter	Current Reference Design Specification
Field of View	AR Display 40° Diagonal; User unobscured FOV 105°
Focal Distance	7.5m - Infinity
Eye Box Size	16 mm V x 10 mm H (18.9 mm diagonal).
Image Resolution	WVGA (854 x 480).
Eye Relief	30 mm (Compatible with Eyeglass Use)
Inter-pupillary Distance (IPD)	Nominally 64 mm. Small IPD adjustment provided.
Colour	Full Color RGB
Brightness (at Eye Box)	10,000 nits (maximum); 10 nits (minimum)
Sequential Contrast	>150:1 (design goal: > 200:1).
Solar Flare	No glare from sunlight/external light sources in eye box.
Operational Temperature	-20C - +80C.
HUD Substrate Thickness	3 mm.
Image Projector Size	20 mm x 20 mm x 10 mm.

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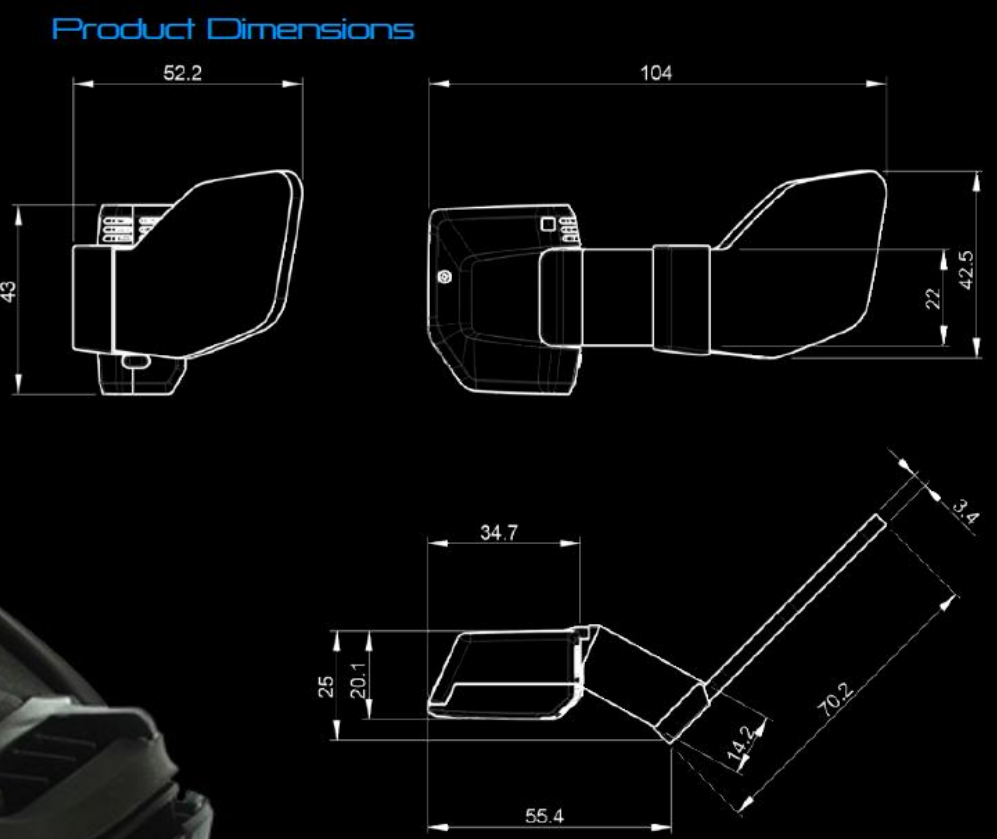
Solving Ergonomics for Regulations



Telematics and Personal Assistant Enabled Applications

Navigation and tracking location of other riders

Engine and bike maintenance

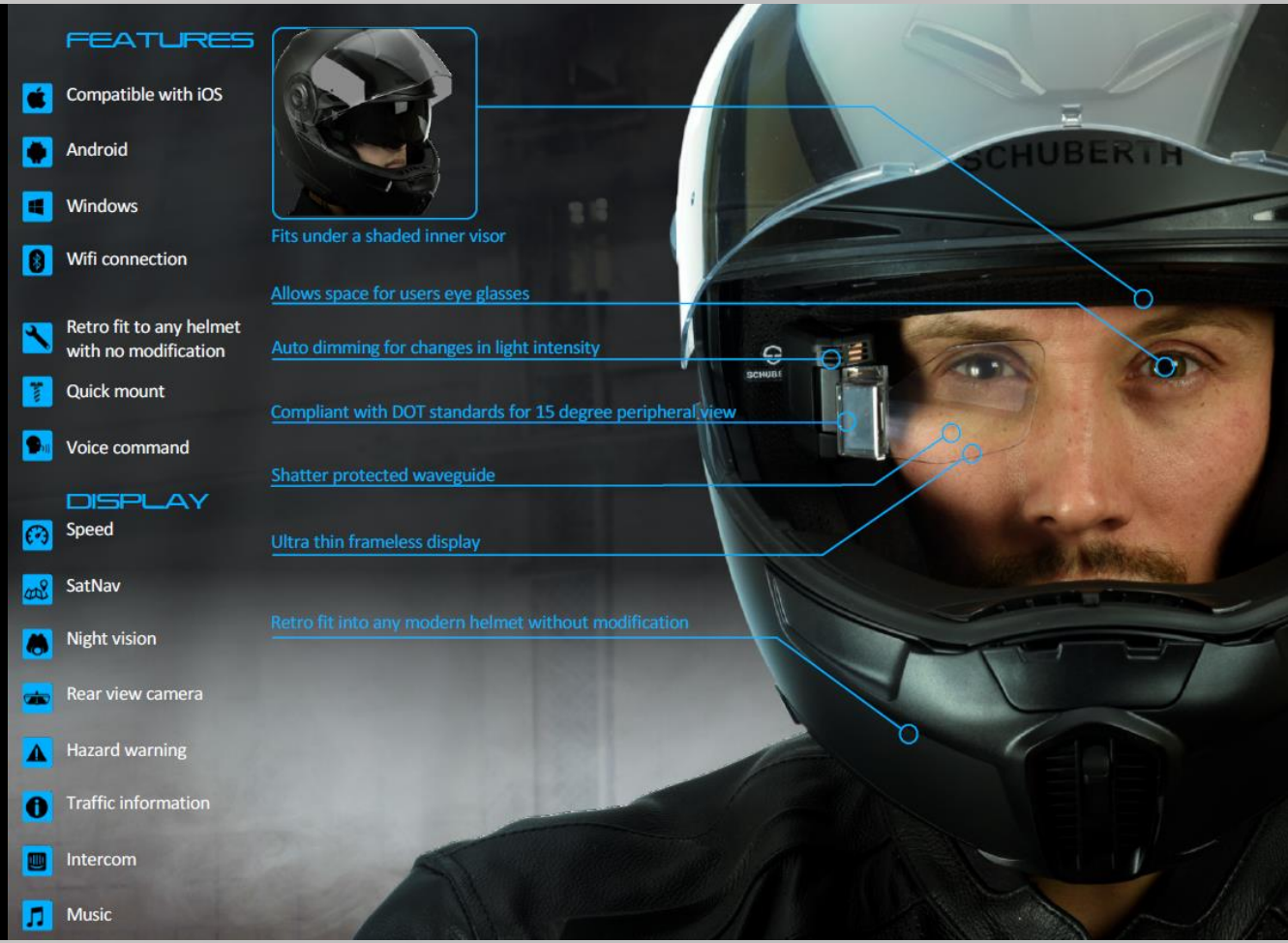
Phone calls

Highlight potential hazards

Speed and navigation

Night vision

MotoHUD for Motorcycling



SnowHUD for Snow Sports

BikeHUD for Cycling

FEATURES

- Compatible with iOS
- Android
- Windows
- Wifi connection
- Retro fit to any helmet with no modification
- Quick mount
- Voice command

DISPLAY

- Speed/ cadence/ power
- SatNav
- Night vision
- Rear view camera
- Hazard warning
- Points of interest
- Intercom
- Music

MonoHUD – Universal, low cost AR display, for multiple applications

Emerging AR HUD Standards

Emerging AR Requirements *(Digital Manufacturing and Design Innovation Institute (DMDII))*

AR HUD Function	Specification	DigiLens AR HUD
Field of View	85 deg. Horizontal and Vertical. 3D view; both eyes full overlapping. Automatic adjustment of IPD No obscuration of peripheral vision (side & up/down)	Design scalable from current 40° to 80-90°.
Resolution	1920x1080	Design scalable from current 854 x 480.
Color	Full color	Prototyping in 2017.
Refresh Rate	120Hz	Compliant.
Eye Tracker	Integrated for software user interface commands	Prototyping in 2017.
Brightness	High visibility (easy to read) display in full ambient light. Brightness adjustment full ambient/dark in 1 s.	
Wearabilty (Comfort)	Head worn weight not to exceed 125 grams. Temperature on user skin not exceeding 35C. Support for prescription lenses.	Currently integrated in production motorcycle helmet.

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Emerging AR Requirements *(Digital Manufacturing and Design Innovation Institute (DMDII))*

AR HUD Function	Specification	DigiLens AR HUD
Environmental	0-50C operation IP64f standard compliant.	Compliant.
Safety	Both intrinsically safe certified & non-intrinsically safe products options. Meeting OSHA and MSHA requirements for safety glasses. Optional side shield safety requirement compliance.	Expected to comply. Eyetracker uses eye safe sources.
Visual Tracking	AR objects scaled and anchored to the physical world. AR object position accuracy to within + 5mm. Capable of scanning QR code (2”x2”) from of 5 ft. from +60° off axis.	Partners to develop. Expected to comply.
Battery Life	Typically, 12 hours minimum	Expected to comply.
Connectivity	Bluetooth wireless and Wi-Fi wireless 802.11 standard.	Partners to develop. Expected to comply.
Inputs/Outputs	GPS; Bluetooth Mouse/ Touch Pad; Bluetooth button Independent device for pointer control Wireless microphone (directional), active noise cancelling, safe: 0-50C. Sound (wired/wireless)	Partners to develop. Expected to comply.

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