Solid State Illumination (Challenges and Opportunities)

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Outline

• Some Context

• Lasers as a Projection Light Source
  • All-Laser Architecture
  • Down-converted Laser Architecture

• Obstacles
  • Speckle
  • Metameric Failure
  • Regulation

• Looking Forward…
SOME CONTEXT
Timeline of Lasers and Cinema (1900-2011)

- 1900 Carbon Arc Lamp
- 1901 Mercury Vapour Lamp
- 1906 First Feature
- 1915 3D Movies
- 1917 Einstein Stimulated Emission
- 1926 Synchronized Sound
- 1952 Cinerama
- 1953 MASER
- 1955 3D Movies 1st Wave
- 1958 LASER
- 1961 CW LASER
- 1963 Xenon Bulb
- 1983 DPSS LASER
- 1985 3D Movies 2nd Wave
- 1988 Star Wars: Episode I
- 2008 National Ignition Facility
- 2009 Avatar
3D Cinema – What’s Happening?

3D Cinema Infrastructure Up, Revenues Down

Big jump in films, screens in U.S. and Canada, but box office declines

Sources: Rentrak, IHS Screen Digest, MPAA
What’s Wrong With 3D?

Low Frame Rates?

Low Light Levels?

Poor Content?
Timeline of Laser Cinema

(1900-2011) (2012-Now)
LASERS AS A PROJECTION LIGHT SOURCE
What is a Laser?

- **Light Amplification by Stimulated Emission of Radiation**

Components
- Gain Medium
- Pump
- Optical Feedback

- Most Interested in Semiconductor Lasers for Projections

Diagram from wikipedia
Higher Brightness

- A lot of laser power (ie light) can be put into a small space
- Still a limit, but it’s much (MUCH) higher than other sources
- How Bright?

- What about Contrast and Depth of Field?

>100,000lm (in the lab)!
Contrast & Depth of Field

- Still cramming more light into a space, but constrain the space a bit for better…
  - …Contrast
  - …Depth of Field
Monochromatic Light

- This is Great because:
  - Simplify optical design
  - Expanded Gamut
  - Can ~choose primaries
  - No IR/UV light
  - No Explosions

- This is Not Great because:
  - Lasers aren’t really like this
  - Narrow band light means it’s coherent, and this leads to speckle
Electrical Efficiency

• Do I get 1W of laser light for 1W of electrical power?
Lifetime

• It is true that a semiconductor device can have long lifetime

• Time between replacement for Xenon <2,000 hours of operation

• How long do lasers last?
  • Depends entirely on how you design the system
  • Cooling system
  • Derating

• Is 35,000 hours possible?
ANY QUESTIONS (SO FAR)?
Remote Light Source
Fiber Coupling

• Why would you use fiber to couple? They’re lossy, right?
  • Yes, and even worse, they’re unevenly lossy

• Yes… but they also offer:
  • Modularity/Scalability
  • Safety
  • Remoteness
  • Simplicity of Manufacture, Installation
  • Portability to other projector applications
Architecture – All-Laser

Generated Light

Displayed Light
Christie Laser Cinema – 2014
All–Laser Pitfalls

• So… Should we stop here?
  • Why wouldn’t we just use this architecture?????
  • Green lasers are inefficient
  • Green laser light speckles A LOT!
  • Red lasers need to be cooled A LOT!

• There are other architectures…
  • Downconversion Architectures

Blue Laser Light

Phosphor

Heat

Green non-Laser Light
Architecture – Laser/Phosphor/LED

Generated Light

Displayed Light

Casio
Architecture – Laser/Phosphor

Generated Light

Displayed Light
Laser/Phosphor – Example
Hybrid Architectures – Pros? Cons?

• To their advantage
  • Still have very long lifetime (no lamp-replacement)
  • Address concerns around Red and Green Lasers
  • Compact
  • Can still have a remote light source

• To their detriment
  • Light from a phosphor goes everywhere, and it’s tricky to collect…
    • Will limit the brightness & contrast more than All-Laser

• Conclusion
  • Not every application requires 70k lumens
  • There are other ways to get contrast
OBSTACLES
Obstacle #1 – Speckle

- Interference pattern
- Figure of merit is “Speckle Contrast Ratio”

\[ \text{SCR}\% = \frac{\text{Std deviation of pixel intensity}}{\text{mean pixel intensity}} \]

- Measurable; acceptable level is subjective
  Observer, content, position, screen type visual acuity, all play a role
- **GREEN** is the most difficult to *acceptably* despeckle – human vision has highest sensitivity/acuity at **GREEN** wavelengths
- **RED** speckle can also be offensive in certain content
Obstacle #1 – Speckle

- Increase illumination angle
- Scramble polarization
- Spectrally broaden the laser output

But Where…?
- In the projector, or on the screen?
Obstacle #2 – Metameric Failure/Mismatch

Diagram from wikipedia
Obstacle #2 – Metamericic Failure/Mismatch
Obstacle #3 – Regulation
Obstacle #3 – Regulation

• Class 3B and 4 “Demonstration Laser Products”
• Currently treated as Traditional Vector Laser Light Shows by US FDA/CDRH
• Requiring Laser Light Show Variance (LLSV) Paperwork, Approval & Related Activities
• Unnecessary and Inappropriate regulations for low-radiance and fixed-install projection applications

• We’ve made a lot of progress on this!
Laser Illuminated Projector Association

- Laser Illuminated Projector Association
- LIPA will speed the adoption of laser illuminated projectors through cooperative industry activity (Mission Statement)

- Who?  20+ Members of the laser projection industry
  - Laser and Projector Manufacturers, Integrators, Exhibitors, etc

- Why?  Address significant regulatory hurdles

- How?  Education, Research, Lobbying

www.LIPAinfo.org
THE PATH FORWARD...
The Promise of Laser Projection

Laser and Laser Phosphor will become Standard Light Sources

• Higher brightness
• More colours, Wider Gamut
• Higher contrast
• Lampless Operation
• Scalable brightness
• Remote Light Source
• Custom White Point
Christie’s Commitment to Laser Projection

• Christie has world-class Laser development programs

• A founding member of LIPA

• Laser commitment shown by parent company’s acquisition of Necsel
  • The world’s leading supplier of projection grade lasers
  • Our competitors buy lasers from Necsel

Lasers are a Platform, Not a Product
Thank you.
Questions?