

## 1. What is true holography ?

Holography is the use of complex microstructures to control the phase of light. Analog holography encodes optical functions by recording their wavefronts in continuous media. Digital holography switches phase in discrete values with pixel arrays. Clarify has extensive skills with both analog and digital holography, and can combine the best features of each domain. In particular, Clarify has decades of experience combining multiple analog holograms within one recording region, and has developed novel optimization algorithms for real-time calculation and display of digital holograms (CGH).

## 2. What are HOEs and holographic light-guides ?

Holographic Optical Elements (HOEs) use holographic techniques to replicate the functions of bulk optical elements, such as lenses, mirrors, diffusers, splitters, combiners, and filters.

Holographic light-guides (also known as waveguides) use HOEs to couple light into an optical element where it undergoes multiple reflections before being coupled out using a second HOE.

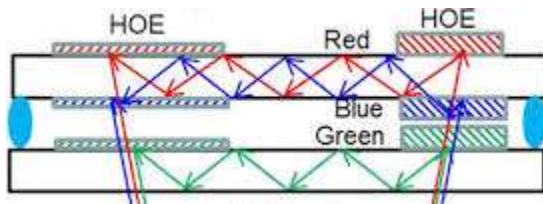
Each HOE can be manufactured using analog, digital, or hybrid techniques. Clarify uses analog techniques for passive elements, because these avoid the ghosting introduced by aliasing in digital techniques, and can encode very complex bulk functions, combined with digital technology for real time elements and switching.

## 3. What are volume HOEs and holographic light-guides ?

Surface-relief HOEs encode their function in two-dimensional surface structures. Volume HOEs distribute these functions through the volume of a thin layer (typically about 6  $\mu\text{m}$  thick), allowing them to be Bragg selective for accurate color control, and highly efficient (>80% for single colors).

## 4. What are their advantages ?

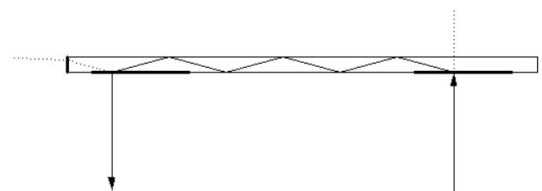
### Conventional digital surface-relief HOE light-guide



[onlinelibrary.wiley.com/doi/pdf/10.1002/jsid.659](https://onlinelibrary.wiley.com/doi/pdf/10.1002/jsid.659) [2018]

- Each surface-relief HOE is single-color, and provides only a single optical function, with low diffraction efficiency, and high noise (ghosting and scatter)
- Multiple layers
- Thick
- Slow and expensive to prototype, difficult to align
- Inefficient, and compromised image quality

### Clarify's approach



Clarify pending US patent [2019]

- Each volume HOE is full colinear color, and can incorporate multiple additional optical functions, with high diffraction efficiency (>30% for each color) and low noise
- Single layer
- Thin
- Can be prototyped rapidly, trivial alignment
- Far higher efficiency, much cleaner beams

## 5. Can I combine HOEs and other optical functions ? In real-time ?

Absolutely ! We can design and fabricate custom HOEs to steer, focus, combine, split, and diffuse multiple beams in multiple colors and multiple independent directions. We can compensate for known wavefront errors, or use our digital CGH capabilities to introduce dynamic changes, such as real-time modification of Zernike polynomials for dynamic digital focus and aberration control. Combined with our other optical and electronics capabilities, this might provide just what you need, in a very compact and simple optical system.

## 6. How small can HOEs be ? How large ?

We've designed entire projection light engines using diffractive optics and LCoS displays small enough to fit inside a cellphone. The biggest HOEs we've made are 14x17 inch on 0.006 inch Polyester, and 8x10 inch on 3.3 mm glass, but we can do bigger if that's what you need. We made the world's largest true hologram (42 square-feet) using our proprietary multiple-exposure techniques. We're happy to help !

## 7. Sounds great: can I have a fully custom part ?

Yes, you can ! Moreover, we can do it fast and cost-effectively. We have a world-class holographic lab and decades of experience. Plus we know just about everyone in the field, so even if we can't do it ourselves, we can get it done for you without you having to sweat the details.

## 8. What is clarify's design cycle ?

Typical prototyping vendors will put you through this...

- You design unfamiliar optics to work with an unproven light-guide technology
- You wait 8 to 12 weeks to get prototypes, which may then not work as advertised
- You have to build and align everything yourself
- Oops, something needs to be changed, back to square one
- Time is money — meanwhile, all of your other activities are on hold, or you must have blind faith that the HOE will work as promised (hint: no, it won't)

Clarify's approach...

- We help you at every step from light source selection, component and vendor qualifications, through total optical system design
- We speak your language
- We offer quick-spin prototyping for holographic optics
- We can assemble and test for you
- We can include multiple holographic functions in the one, full-color element
- Fast, cheap, discreet... try it early, iterate to the best solution

## 9. Who / what / why / where ?

We are a small well-connected group of dedicated opto/electronic engineers in Phoenix AZ, with decades of experience in holography (HOEs, pictorial, CGH/digital), numerical software, optical analysis/troubleshooting, analog & high-speed digital electronics, and systems engineering.

We can assist at every step of new product/technology introduction, with a total commitment to clarity, so there are no mistakes, no surprises, no slippages.

For more of our propaganda, please see our web site at [clarify.one](http://clarify.one) or talk with us. We're nice people to work with !

## 10. Support ?

Yes ! Just ask for what you need. We are constantly improving and extending our offerings based on user feedback and our own applications. Talk one-on-one with our engineers when that's what you need.

## 11. Show me !

At our booth this year we're showing :

- Prototyping capability for multicolor holographic light-guides and HOEs
- Large HOEs on glass and plastic substrates
- Interactive phase CGH game with real-time digital focusing and multiple holographic sprites
- Online CGH generation as a service
- Talk with our engineers about custom optoelectronic prototyping, design, and consultancy services

Also see our clariFAM modular, extensible TEC and laser-diode controllers :

- Interactive CIE color-mixer, using color sensing via clariCTRL, with RGB lasers under PWM control from a touchscreen tablet
- Accelerometer protected laser, using clariCTRL & clariLDRV — lasers color cycle... until you hit it to lock in the current color
- Custom clariMNTs for Sumitomo and LaserLand lasers
- The full set of clariTALK comms modules