Innovative and Dependable Approach for Recording True-Color Transmission Holograms Free from Crosstalk Artifacts

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Abstract:

This article presents a holographic configuration for recording true-color transmission master holograms, developed in France by Hololab-Factory. The advantage of this approach is that it allows for the production of color master holograms, effectively eliminating ghosting (crosstalk imaging) systematically generated during recordings, whether using three separate beams (RGB) or coaxially combined into a single white beam. After a transfer (H1 to H2), this technique produces a final color reflection hologram. This hologram is distinguished by its high efficiency, balanced color harmony, large aperture, and depth of field.

Keywords: true-color transmission holograms, crosstalk imaging, Hololab-Factory,

Introduction:

Currently, the recording and reconstruction of color holograms can be achieved in many different ways, ranging from the simplest techniques such as the Denisyuk hologram to more advanced methods, extensively detailed by numerous authors in the specialized literature.
Although each has its own specific advantages and disadvantages, these techniques fall primarily into two categories: reflection holograms and transmission holograms.
Furthermore, high-resolution (panchromatic) color recording media are now available that are specifically adapted for recording these holograms, such as silver emulsions and photopolymers. Unlike silver halide emulsions, photopolymers do not require chemical processing for development and offer excellent diffraction efficiency when used correctly.
Although the color holograms of the "Denisyuk" reflection type lend themselves easily to reconstruction in unidirectional white light, and are therefore the most frequently encountered, they do not allow for obtaining high-efficiency holograms, given that it is not possible for this type of configuration (single beam) to control, on the one hand, the Object/Reference illumination ratio, and on the other hand, the presence of pigments when the blank film presents a significant (bluish) coloration, linked to the pigments used to sensitize the film to the different colors, and thus hinders the transmission of light intended to illuminate the object located near the film. This lack of transparency linked to this coloration of the photopolymer film further limits the maximum achievable efficiency, by further reducing the Ref/Object ratio.

Now considering the transmission color holograms, one of the primary challenges encountered during their reconstruction arises from the necessity to illuminate them with identical wavelengths and directions as those used during the hologram's recording.
For instance, when using a red laser for a transmission hologram, it not only recreates the image associated with that color from the recorded red fringes but also generates a smaller, slightly displaced image from the recorded green fringes, along with another smaller, shifted image from the blue fringes.
The same issue occurs with green and blue lasers, leading to a total of three images for each color instead of just one, resulting in six unwanted ghost images out of the nine produced.
Finally, the fact that three sets of fringes are recorded on the same space of the film, produces a reduction in the fringe contrast, which reduces the resulting overall efficiency.

Considering all these data, the present research proposes an optimized recording method for the production of transmission-type holograms without the presence of unwanted ghost images, capable of being transferable to second-generation reflection-type holograms, visible in white light and with high efficiency.

Proposed method:

This device consists of a first independent optical bench, comprising three vertically polarized (RGB) lasers, individually controlled by three silent electromagnetic shutters, and driven by a programmable electronic timer with three independent channels.
This allows a different exposure time to be assigned to each color, to control the final color balance. Beam shaping is carried out by a set of dichroic mirrors on adjustable optomechanical mounts, enabling the three beams to be aligned and juxtaposed, to obtain a single combined white beam.

This beam is then sent to the second optical bench, on which all the optical supports and components are arranged, before arriving at a variable beam splitter which divides it into two beams, one reflected (object beam) and the other transmitted. (reference beam)
(fig.1)
The object beam is reflected by a set of two mirrors and arrives at the 10X objective, which illuminates the object.
The transmitted beam is reflected by a mirror onto a prism at an angle Θ=40°, allowing it to be broken down into its three initial RGB components.

These three RGB reference beams are then individually redirected onto three small mirrors to be respectively sent at different angles into three space filters equipped with X4 objectives and 10µ pinholes.
Green reference beam: On leaving the space filter, the cleaned beam is directed onto a set of two large horizontal mirrors positioned opposite each other, the latter being judiciously placed high up so that it hits the photosensitive support at an incidence of 56.7° (Brewster angle).
Red and blue reference beams: After passing through a spatial filter, these cleaned beams are respectively directed onto large vertical mirrors on either side, so that each of them arrives on the film at the same 56.7° incidence.
(Ideally, for each of these reference beams, the mirrors should be parabolic and of the off-axis type, to obtain perfectly collimated beams)

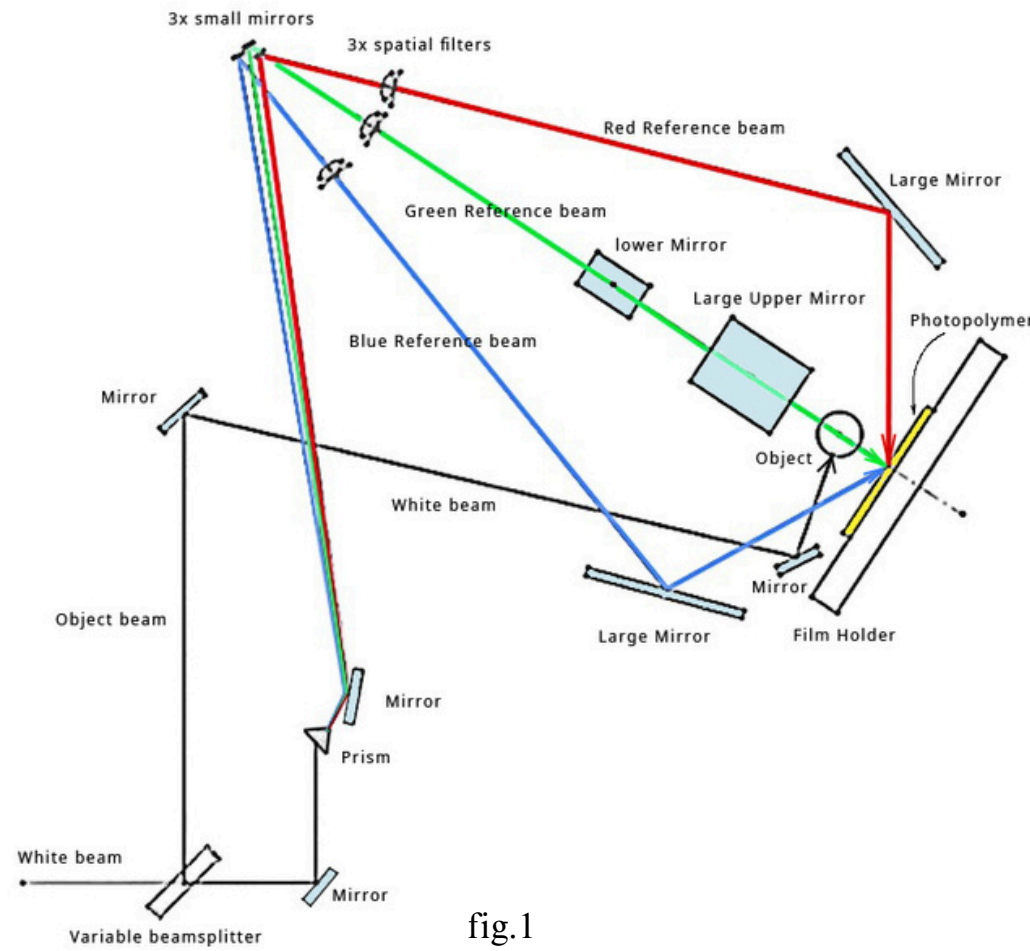
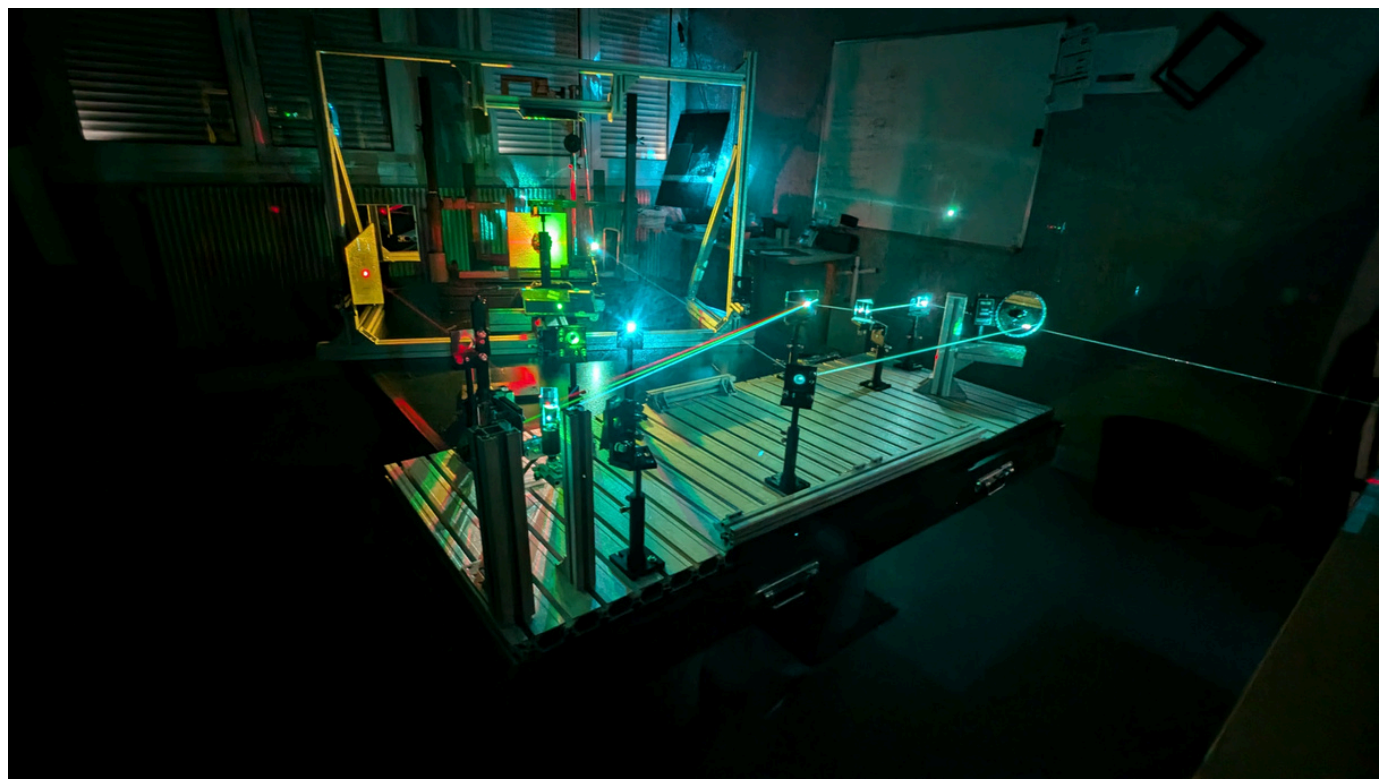
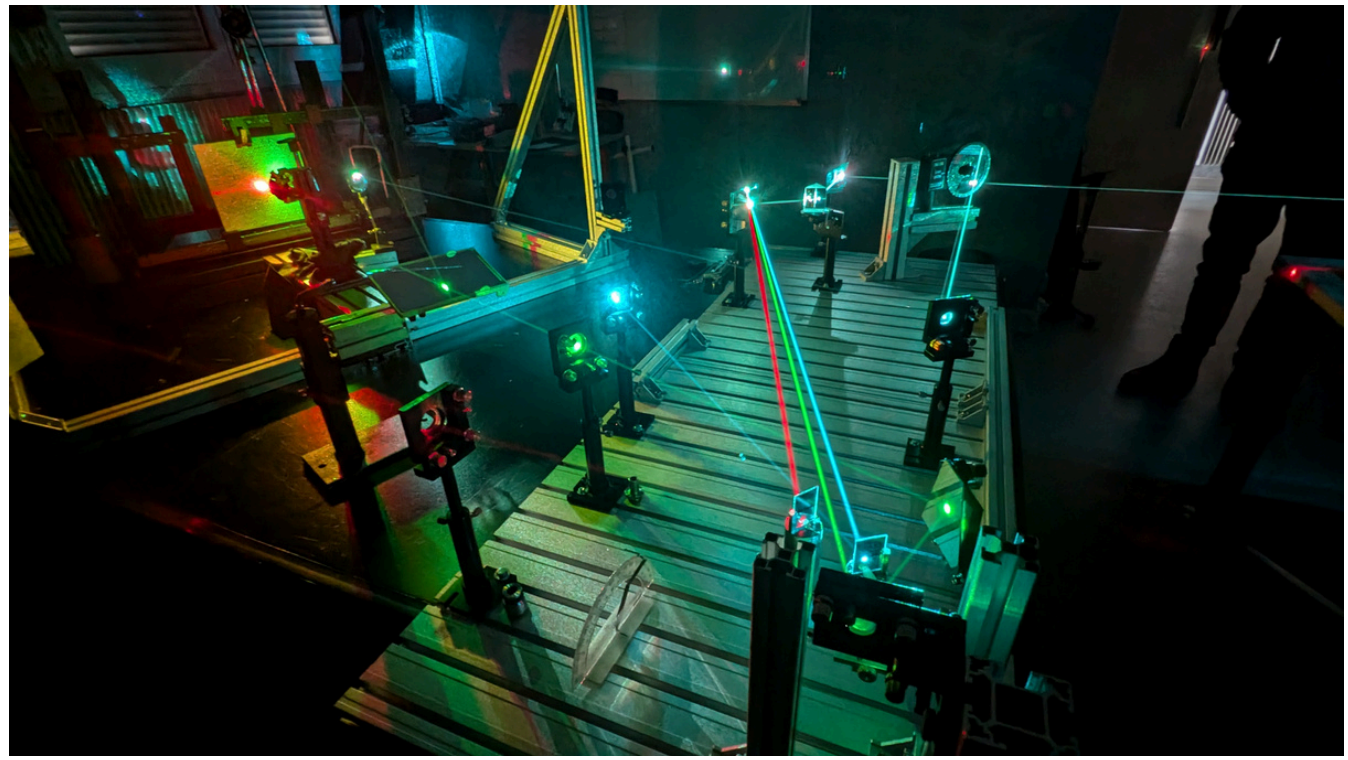
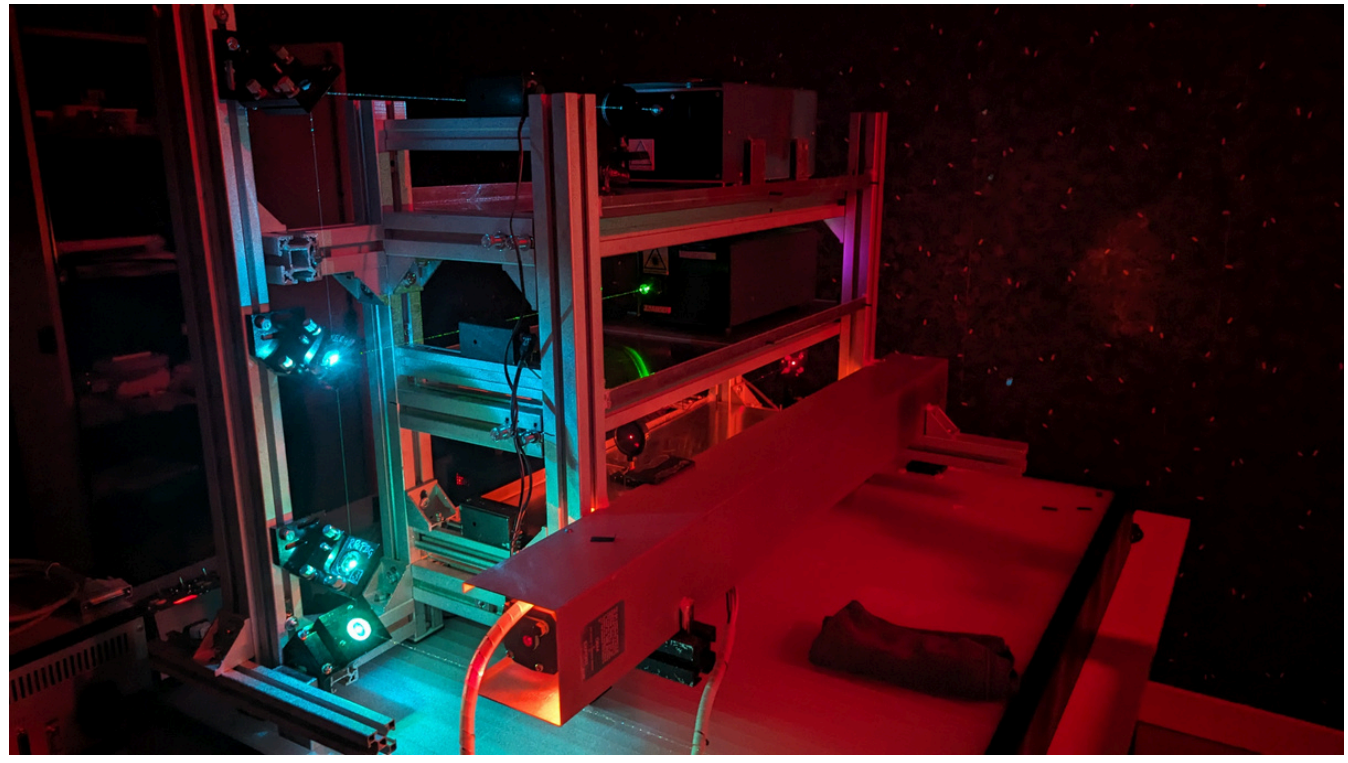


fig.1

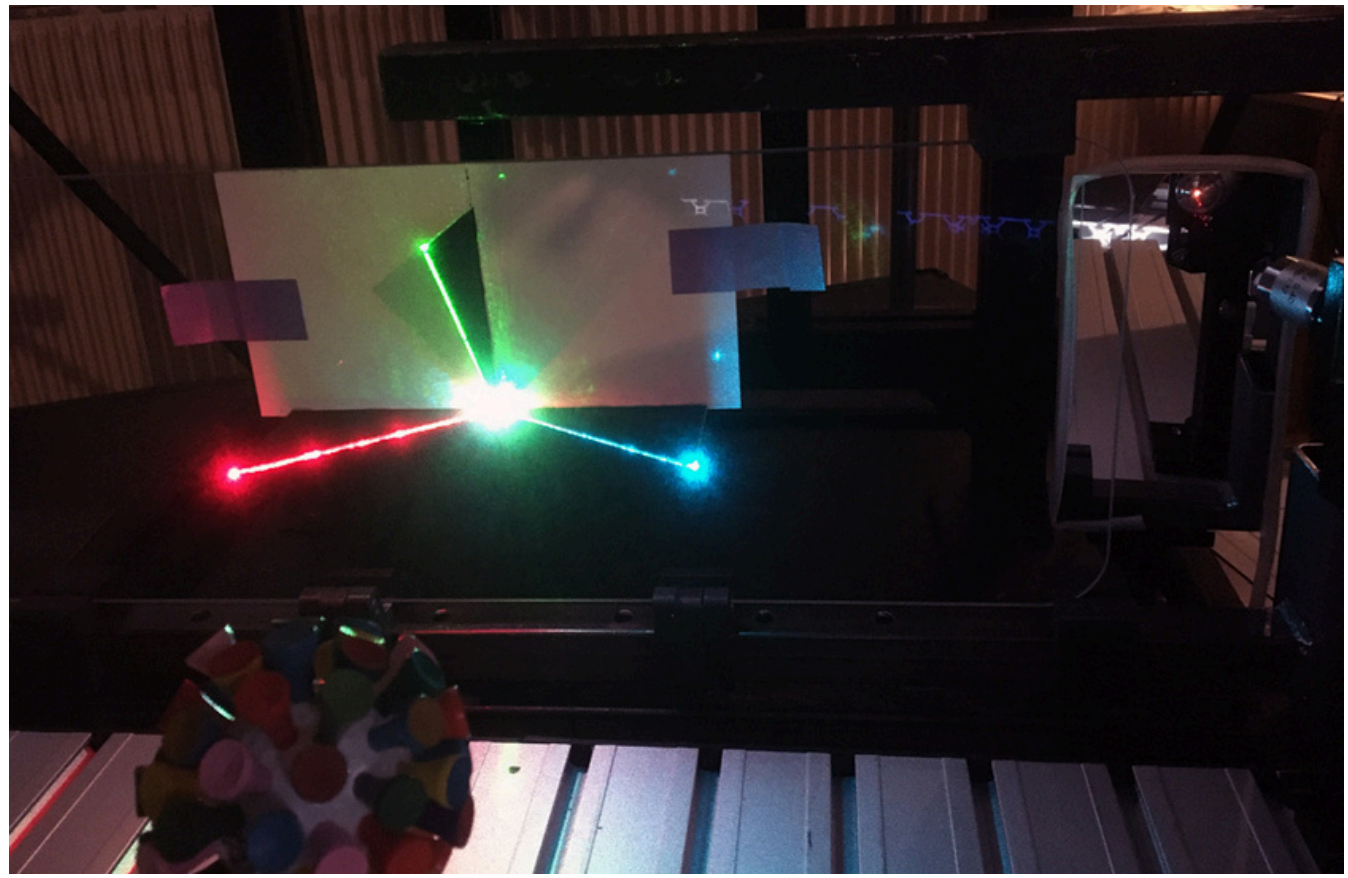


Overview of the optical device

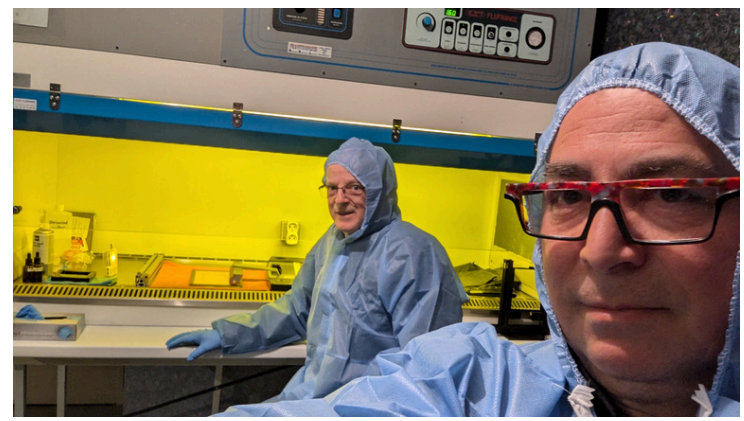




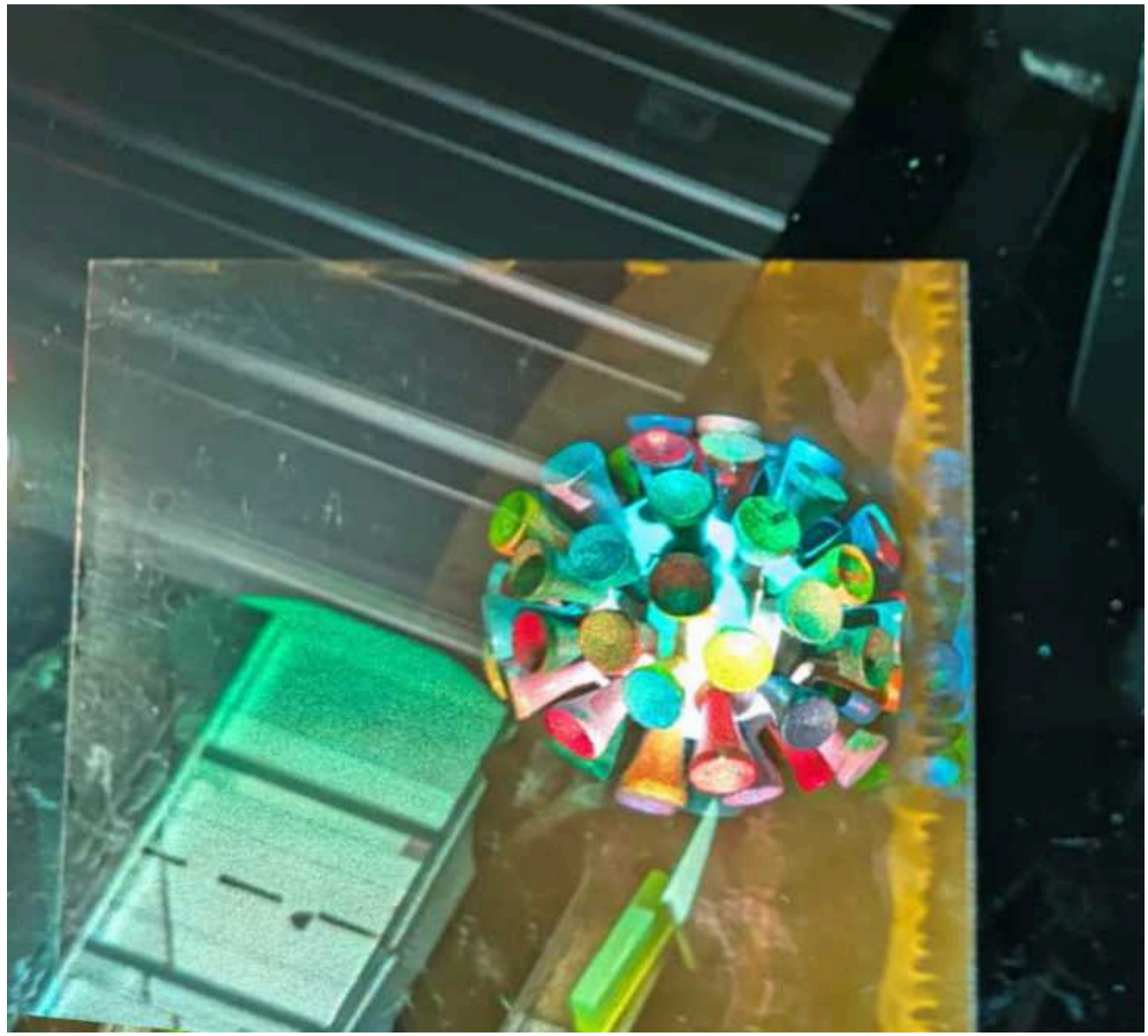
View of the laser bench



View off the alignment guide for the three reference beams at Brewster angle.



Laminating HX200 film under laminar flowbox



View of the final transmission hologram acquired.

Conclusions:
This approach facilitates the production of high-quality color transmission holograms. However, it necessitates specialized equipment and should be paired with off-axis mirrors to guarantee well-collimated reference beams. Without these components, achieving precise alignment of the three RGB elements during the H1/H2 transfer reconstruction (real pseudoscopic image) may pose challenges.

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