Hololab-Factory

JCT mai 2026

Feedback on the use of COVESTRO HX200 photopolymer

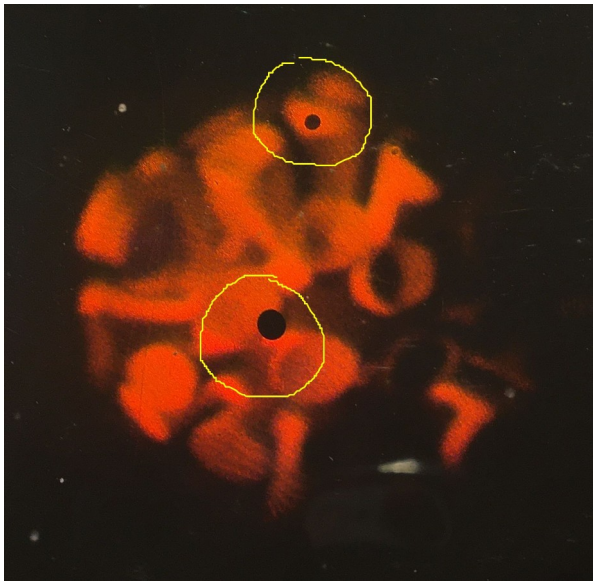
Although this material has many intrinsic qualities (high diffraction efficiency, panchromatic sensitivity, absence of chemical process, price, etc.), there are nevertheless some disadvantages to its use and precautions for use to consider and respect in order to obtain good holograms.

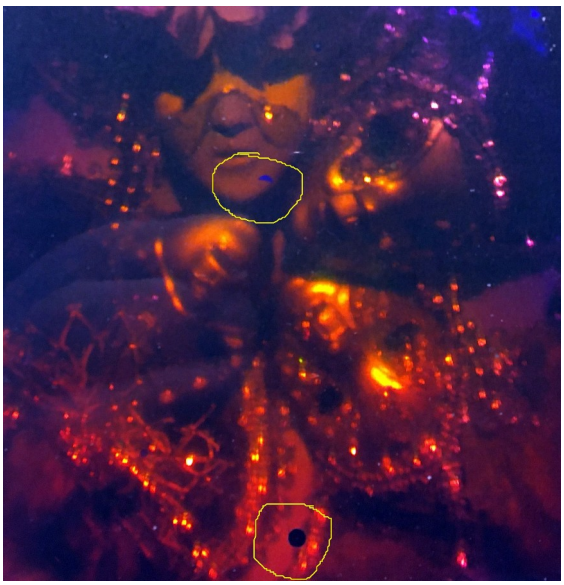
- The very thin substrate (60 µ) of the HX200 film is a Cellulose Tri-acetate (TAC) which remains very sensitive to scratches and micro scratches.

- The thinness of the HX200 film also makes it easily tearable during various handling operations related to its lamination or delamination from its recording medium.

- The HX200 film is very electrostatic, and its active surface is sticky (monomer layer), which makes it a real “dust catcher” once its protective film is removed.

- If air bubbles or dust become trapped between the photopolymer and the glass substrate during film lamination, this systematically results in "black spots or bubbles" after recording, which are clearly visible in the image upon playback.
During the recording process, the air trapped in these bubbles experiences a rise in temperature due to the effect of light radiation. This increase in temperature then induces the formation of localized thermal shake zones.



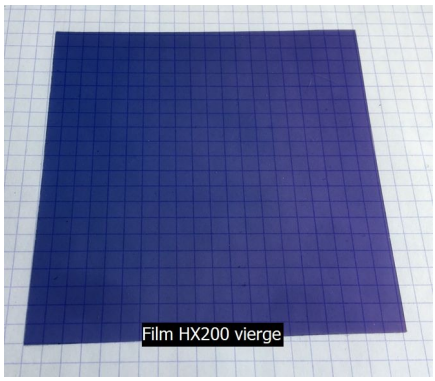


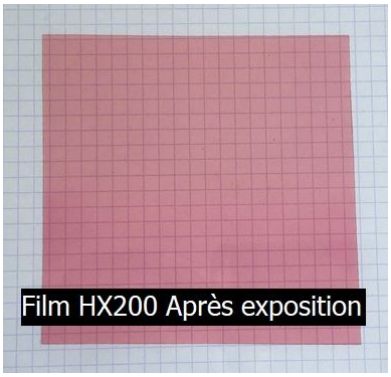
- Hence the almost necessity of handling and laminating this film under a laminar flow hood (filtered air overpressure), to guarantee correct installation on the glass plate.

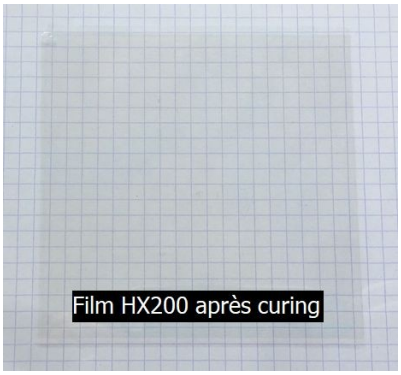
- Even after the final post-curing operation (UV exposure), the HX200 film remains sensitive to solvents present in the glues of the black adhesive supports laminated on the emulsion side, or the spray paints used to blacken the back of the film. Acrylic paints, on the other hand, adhere quite poorly to this support.

- When the film is blank, it has a significant (bluish) coloration, linked to the pigments used to sensitize the film to different colors.

In the case of a Denisyuk-type hologram recording, the lack of transparency linked to this coloration of the HX200 film further limits the maximum achievable efficiency, by reducing the Ref/Object ratio, which is much more favorable for a panchromatic silver film, which is practically transparent.







- For the same holographed object, the overall diffraction efficiency or yield of a Denisyuk-type color reflection hologram (RGB), recorded on HX200, was analyzed and compared to the maximum efficiency obtained on this same medium for a monochromatic (single color) recording.
- The results obtained clearly show that the overall efficiency of the color hologram (RGB) is 2 to 3 times lower than that of the same monochromatic hologram.

- HX200 film exhibits a strong sensitivity to the luminous non-uniformity of the reference laser beam. This phenomenon results in clearly visible dark delineation areas in the reconstructed image, despite a deceptive initial visual appearance of uniformity of the coverage area.

- The use of a well-calibrated optical power meter for each respective wavelength appears essential to ensure optimal uniformity of the light coverage area. Similarly, without the use of a spatial filter and given the high sensitivity to this exposure non-uniformity, the diffraction patterns of dust possibly present in the lens or on mirrors for example, will be clearly marked and visible in the final image.





- When using three independent lasers (RGB) for recording true color holograms, it is imperative to ensure good color rendering or color balance, to balance the distribution well and to obtain almost perfect uniformity of the coverage area of the recorded film format, for each color.

- The blue rendering is better for choosing a wavelength at 473nm than at 488nm.

- Choosing RGB exposure using simultaneous or sequential exposure:

Regarding color balance optimization, it is preferable to expose the three primary colors simultaneously (at the same time) rather than proceeding with "sequential shots," i.e., successively recording the different red, green, and blue colors.
The choice of a sequential approach produces a significant color preponderance in the final hologram rendering. This is attributable to the higher efficiency obtained for the first initial color recorded, at the expense of the following two.

- Intriguing light pulses (flashes), varying in speed and intensity, seeming to emanate from the surface of the HX200 photopolymer during the active photopolymerization phase of hologram recording, can sometimes be observed.

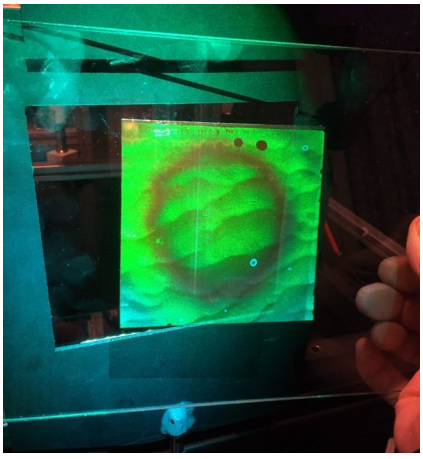
I believe this is the visualization of light interferograms, which would be generated by the exothermic reactions of the HX200 photopolymer, and/or by possible sources of vibrational disturbances.

- **Luminous power density: a crucial parameter.**

Luminous power density (RP) is defined as the light energy received per unit area, expressed in milliwatts per square centimeter (mW/cm²).
For the HX200, the density defined in the COVESTRO datasheet is 4.6 mW/cm², but it remains specific to the particular setup created and described by the manufacturer for this characterization. In fact, it cannot correspond to the real-life case of a conventional Denisyuk-type hologram recording. The reference angle is not Brewster (56.7° minimum reflections) but is 22°, the polarization is mismatched (S versus P), the substrate thickness is very thick (thermal scattering), the ratio is compensated (Ref/object equal to 1) at the emulsion level, and the object to be holographed is non-absorbent and non-scattering, since it is simulated by a reflective mirror.

- Experimentation in real and usual conditions shows something completely different, and highlights a new problem directly linked to this energy level of power density (PR), by the appearance of "moving zones" generated by the thermal heating of the HX200 and/or the glass substrate, during exposure during its photopolymerization phase.

This thermal expansion results in “zones of motion” (presence of a veil or central or central annular dark spots), particularly more sensitive for green and blue colors, at shorter wavelengths than for red.



- The critical threshold observed during our experiments appears not to exceed 0.75 mW/cm² in cumulative energy (R+G+B) for a 10x10 cm film, laminated on a standard quality flat glass substrate, 4 or 6 mm thick and 19x24 cm in size.
Exceeding this threshold systematically generates these undesirable thermal motion zone defects.

- A "sandwich" of the film between two glass plates (one of which can be anti-reflective) makes it possible to improve the thermal diffusion of the HX200 through these two substrates, and thus makes it possible to raise the critical threshold from 0.7mW/cm2 to nearly 1.05mW/cm², without generating these problems.

- Although expensive, the use of borosilicate glass plates (tempered glass) with a very low coefficient of thermal expansion remains the best solution to overcome this problem of "thermal movement".

- While using the Brewster angle to record a Denisyuk-type hologram offers significant advantages in terms of reducing energy losses and unwanted reflections through increased radiation transmission, this approach is not as advantageous as hoped. Indeed, it produces at least three major drawbacks.

First, it is imperative that the reference beam be non-divergent and perfectly collimated (parallel beams) to satisfy the Brewster condition.

Second, at this angular value (~56°), it produces long shadows cast on the object, which is not always the most effective.
Third, it is necessary to use a near-grazing reconstruction angle to achieve the Bragg condition during reconstruction, due to the observed angular shift, which is not negligible.

- **Angular Bragg Shift During Hologram Reconstruction**

During our experiments with the panchromatic **Bayfol HX200 photopolymer**, we observed an angular shift in reflection holograms between the angle used during recording and the angle at which diffraction efficiency reaches its maximum during reconstruction. This phenomenon, referred to as an *angular Bragg shift*, results in a change in the optimal reconstruction angle relative to the original recording geometry.

Under our experimental conditions, this shift was found to be approximately **8° to 10°**. It is therefore important to take this effect into account when setting up the recording geometry, particularly when a specific reconstruction angle is desired.

Practical example: if the objective is to reconstruct the hologram with maximum diffraction efficiency at an angle of 30°, it may be necessary to record it at an angle of approximately 40° to compensate for the observed shift.

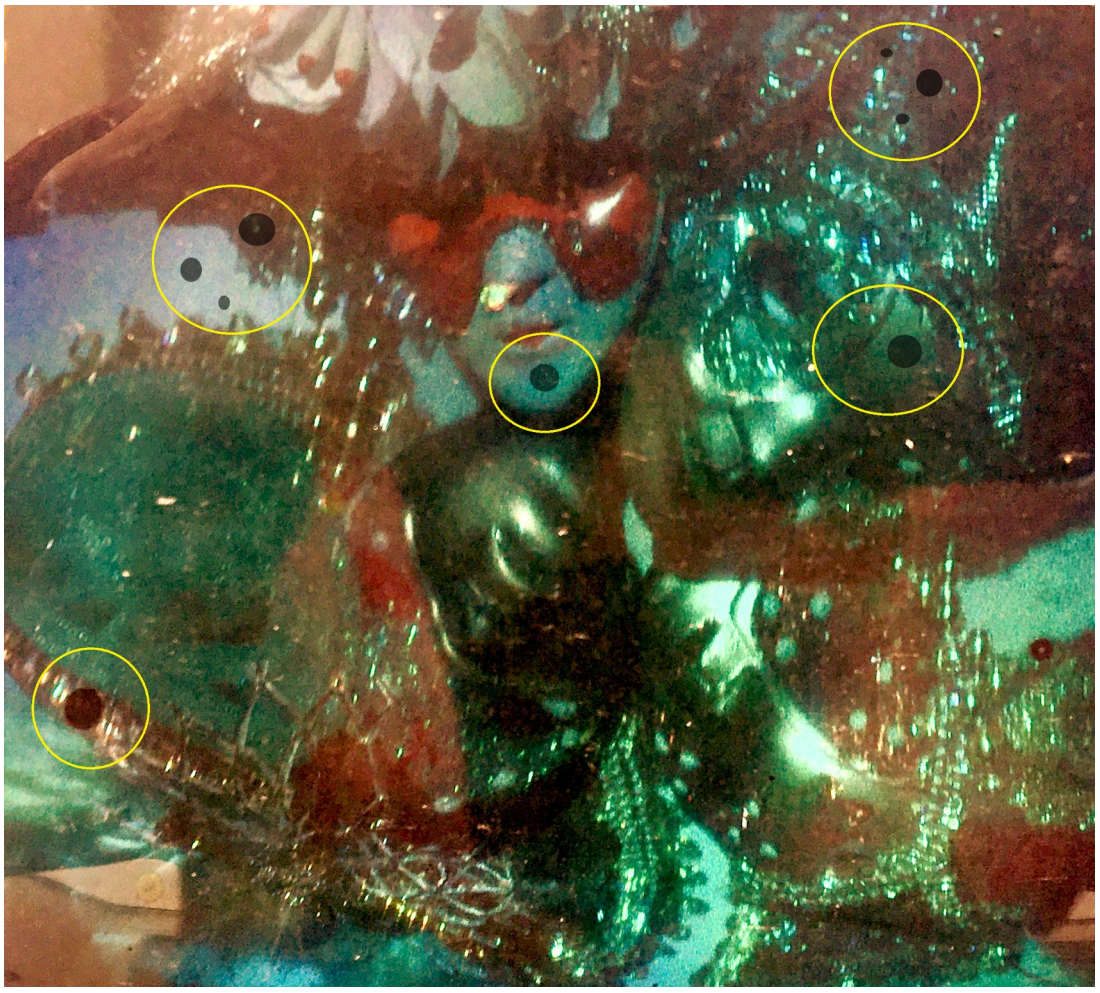
This angular correction is an indicative experimental value observed in our reflection holograms recorded using Bayfol HX200. It should be verified according to the recording and reconstruction conditions, as well as the optical geometry employed. Preliminary tests are therefore recommended to determine the precise correction required for each configuration.

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Procedure for Optimized Coating and Lamination of HX200 Photopolymer

If, like us, you use HX200 photopolymer for recording your holograms, you have probably encountered the recurring problem of small black spots appearing and irreversibly degrading the final quality of your work (see photos below).



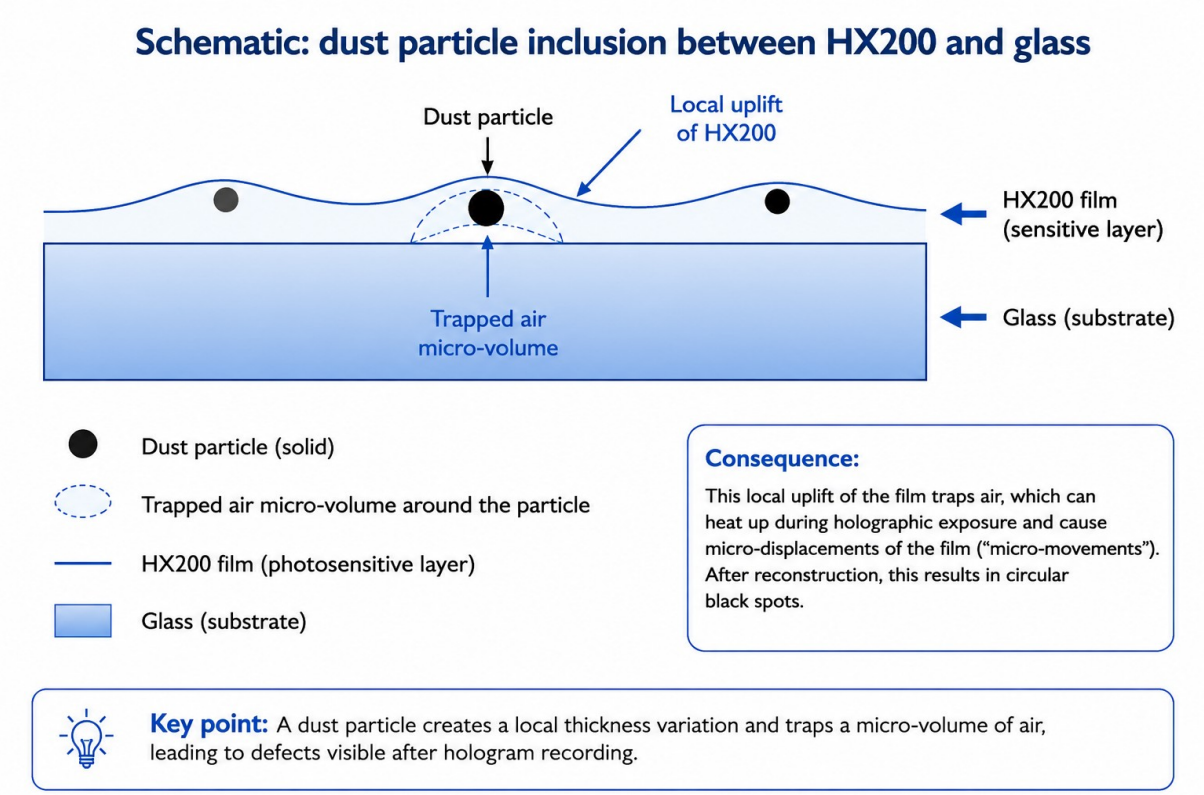
These defects are mainly caused by the presence of dust particles that settle, due to electrostatic attraction:

- either directly on the glass plate;
- or on the adhesive-sensitive layer of the HX200 film.

This contamination generally occurs:

- when removing the protective film from the HX200;
- and/or during the lamination process of the film onto the glass substrate or any other support, usually carried out using a pressure roller.

Origin of the Black Spots



These particulate inclusions, visible to the naked eye for the largest particles or under magnification for the smallest ones, locally create an excess thickness between the photopolymer and the substrate.

This local deformation also traps a small volume of air around the particle. During holographic exposure, this trapped air can slightly heat up and generate localized micro-movements of the film ("micro-shifts").

After hologram reconstruction, these disturbances appear as circular black spots that are more or less visible depending on:

- the size of the particle;
- the amount of trapped air;
- the exposure conditions.

Tested and Validated Solutions

To date, we have not yet found a method capable of guaranteeing the total elimination of this problem in a standard environment. In practice, only a lamination process performed inside a clean room would completely eliminate this issue.

Nevertheless, several combined solutions have made it possible to reduce the appearance of these defects very significantly.

1. Reduction of Electrostatic Charges

The use of a negative ion generator has proven particularly effective in neutralizing electrostatic charges present:

- on the glass plates;
- on the HX200 film;
- as well as in the immediate working environment.

This neutralization greatly limits the attraction of dust particles to sensitive surfaces.

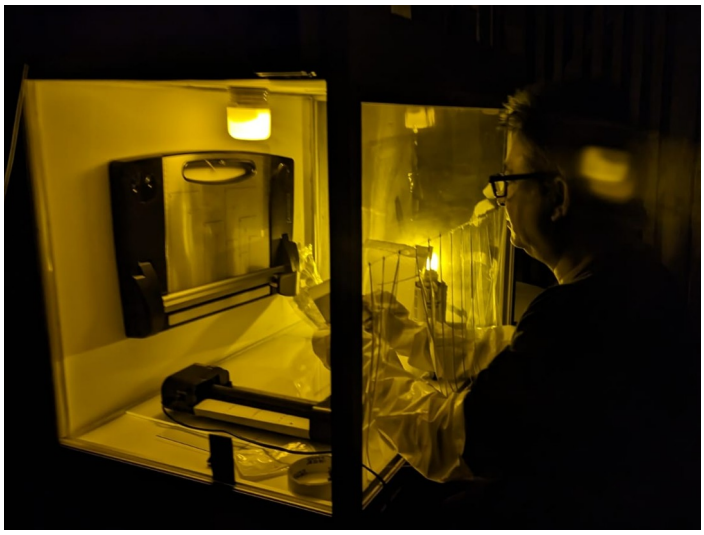
2. Lamination Under Filtered Airflow

Performing the lamination process under a positive-pressure filtered-air Flow Box considerably reduces the amount of airborne particles present in the working area.

This solution significantly improves environmental cleanliness during critical film handling operations.



Flow Box with filtered positive-pressure airflow.



DIY Flow Box operating setup.

It is possible to build such a small positive-pressure Flow Box yourself, as shown in the example below or as we did before acquiring an industrial model.

YouTube link: https://urls.fr/1gaYdp

3. Thorough Cleaning of the Substrates

Extremely rigorous cleaning of the glass plates before use is essential.

We recommend:

- cleaning with “Blanc de Meudon” (calcium carbonate);
- thorough rinsing with demineralized water;
- final cleaning with isopropyl alcohol;
- the use of non-woven lint-free wipes;
- filtered air blowing;
- as well as systematic inspection under grazing light before film lamination.

4. Prevention of Human Contamination

A significant portion of contamination comes directly from the operator:

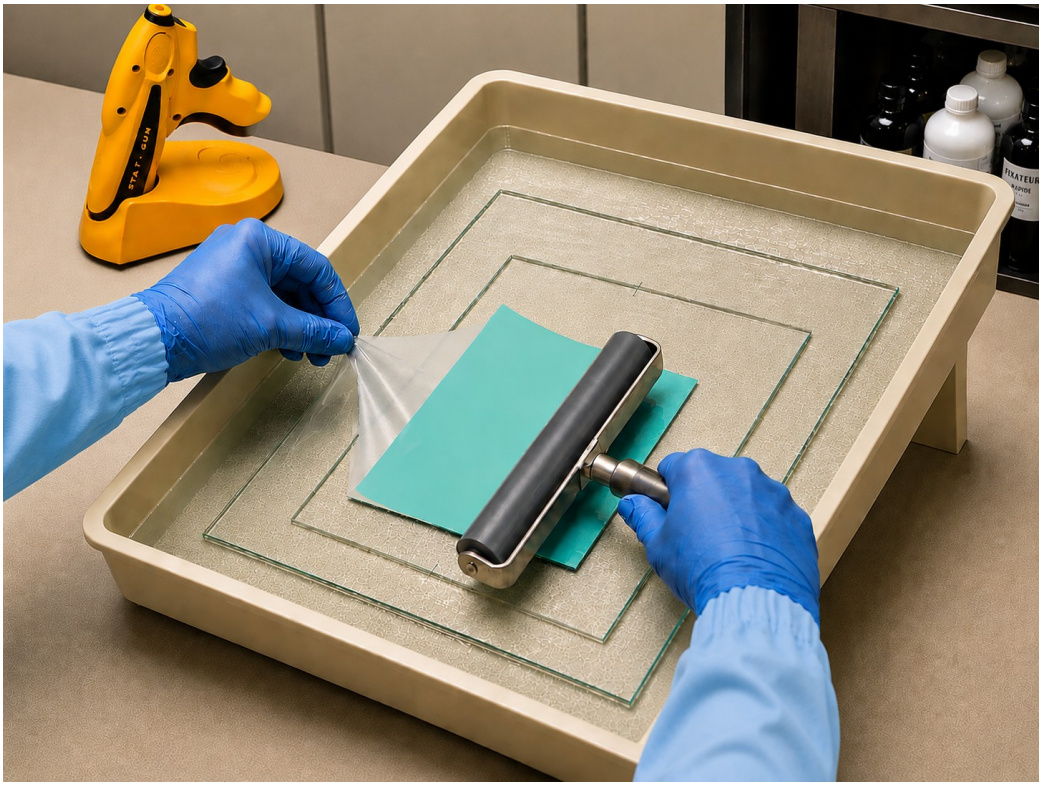
- textile fibers;
- dust;
- skin flakes;
- eyelashes, hair, or microfibers.

To limit these contaminants, we use:

1. a dust-proof suit worn over clothing;
2. latex or nitrile gloves;
3. as well as handling reduced to the strict minimum.

5. Lamination Under Liquid Immersion

One of the most effective methods we have tested consists of performing the lamination under immersion in filtered demineralized water.



This technique offers several advantages:

- it does not alter the quality of the HX200 film;
- significant reduction of airborne dust particles;
- limitation of electrostatic effects;
- improved contact between the HX200 and the substrate;
- reduced risk of trapped air.

However, this method requires:

- filtered demineralized water;
- a clean environment;
- and careful handling in order to avoid any secondary contamination.



Handling the HX200 photopolymer in a filtered-air environment with anti-contamination protective equipment.



Laminar flow hood used for critical lamination and inspection operations.

Conclusion

The lamination of HX200 photopolymer is an operation that is particularly sensitive to particulate contamination and electrostatic phenomena.

Although it remains difficult to obtain a result completely free of defects outside of a clean-room environment, the combination of:

- electrostatic control;
- a clean working environment;
- rigorous cleaning procedures;
- and immersion lamination,

makes it possible to significantly improve the final quality of holograms and greatly reduce the appearance of black spots related to dust inclusions.