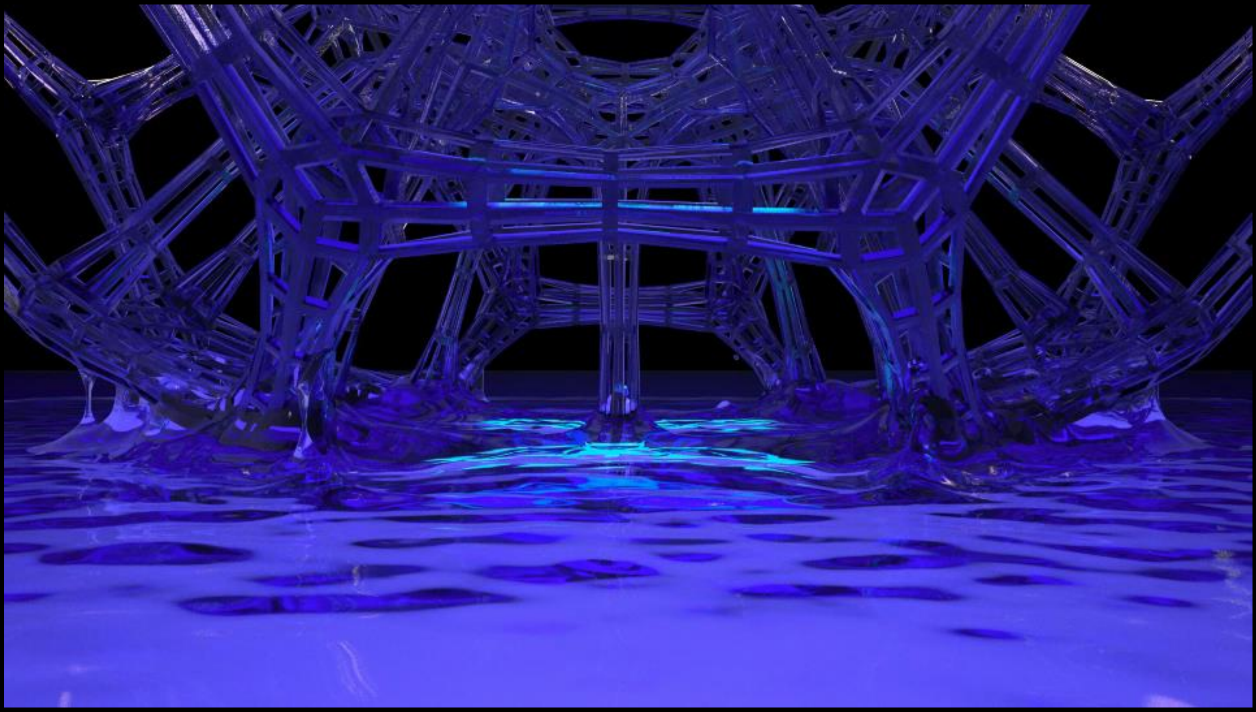
Fusion CI Studios
…incomparable fx

Case Study: Carbon 3D

When Carbon 3D announced its groundbreaking 3D printing process, CLIP, at a Vancouver TED talk, Fusion CIS partnered with Cinco Design to create an artistic depiction of how the printer works. As if by magic, the printer creates 3D objects 25x faster than typical printers via an interaction of laser and resin. Fusion's visuals had to artfully represent this phenomenon of laser-light and liquid and the reaction it generates. With only 3 weeks to create the sequence, it was a steep climb but the Cinco and Fusion teams worked closely together and managed to hit the creative target and concoct some gorgeous imagery. Here it is!



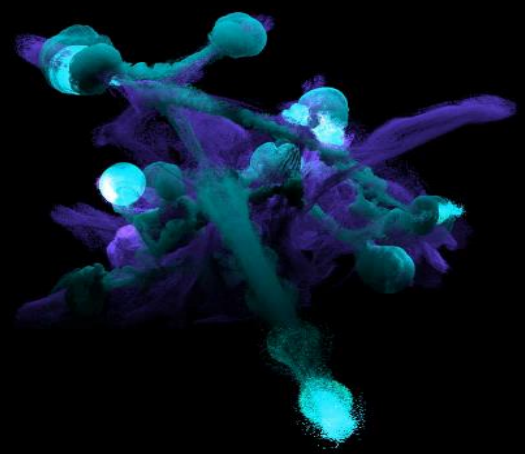
Final Movie

Cinco created previz maya scenes containing the rising animated 3D geometry (a complex "buckyball") and camera for all shots above the surface of the resin bath. Fusion created the visuals for the nebula-like resin/laser reactions (RealFlow, Fume FX & Krakatoa), the simulation of the resin interacting with the buckyball (RealFlow & Smorganic) and the shading/lighting/rendering (Maxwell). Cinco composited & finished, adding lens flares, atmospheric fogs, and depth of field blur.

Below Surface Shots: Chemical Reaction Nebula

Genesis: In the first few shots, Fusion devised a nebula-like particle system using a combination of RealFlow, Fumefx and Krakatoa. Custom RealFlow particle simulations were created as the source chemical reactions, and used as the source for Fumefx sims, which were then given a Krakatoa treatment. The end results were rendered with Krakatoa. The first shot is a close-up of the genesis of the light and resin chemical reaction…

See Genesis



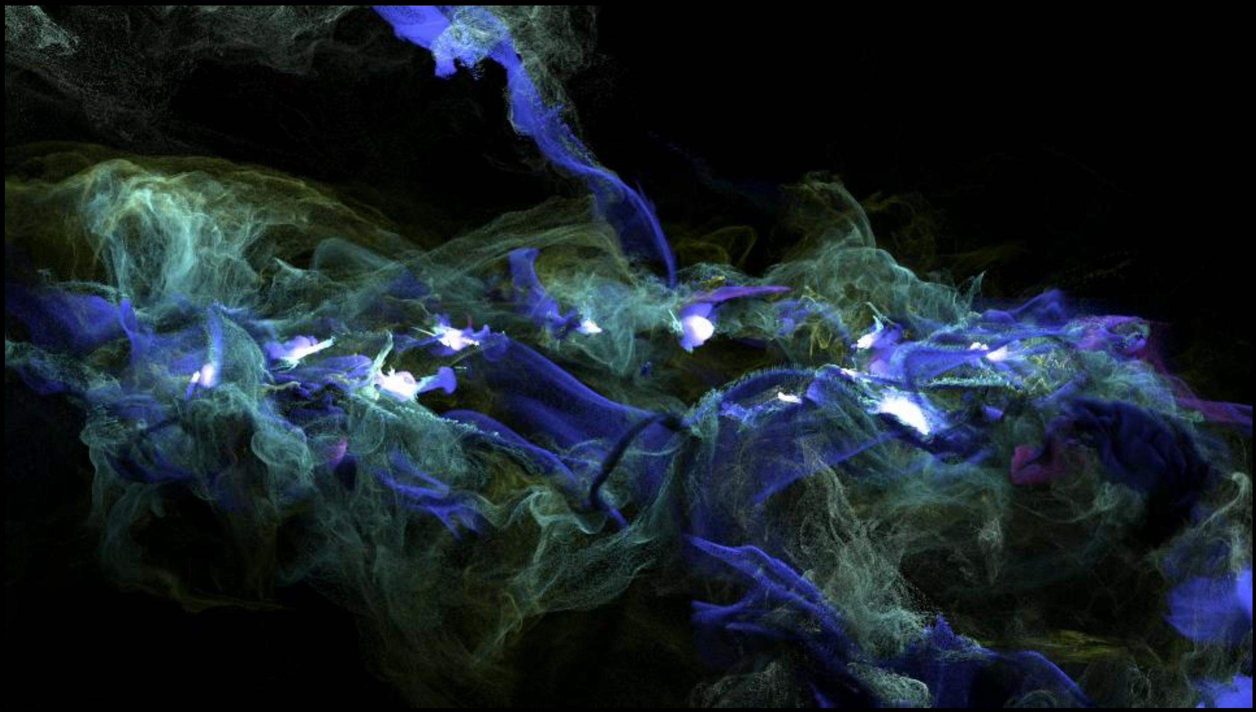
Here we wanted specific, art-directed control on the motion of the lights, so we hand-animated the movement of the leading point of light (a small sphere) and the birthing of additional light points (spheres) from the lead light. We then ran a particle system simulation in RealFlow which added a sparse particle coating on the animated spheres and trails behind these coating particles as dense linear threads. The thread sim originates from our work on an AMEX project, where we created ethereal, aurora-like trails behind athletes & musicians. The threads are tightly-packed lines of particles that are pushed around with gentle forces like noise, and are kept tightly-packed using a particle interpolation algorithm. These tight threads make good sources for FumeFX smoke.

Here's a preview of the thread sim used as FumeFX sources:

We also created visible lights on the tips of the trails, and a splashy little burst of particles to kick off the shot, and instanced small irregular fragments of geo on these particles with spin controlled using simple expressions. These were rendered with a metallic shader to get a nice sparky burst: The Element

We created 2 FumeFX sims, one for the particles coating the light point spheres, which were eventually rendered as predominantly green, and the other using the trailing threads as sources which were predominantly blue. In 3dsMax, we parented omni lights to the spheres and controlled the color and density of the Krakatoa particles as a function of particle age using a magma flow setup. This allowed us to bring in hints of magenta, which were part of the client-approved color palette. Here's a closer view of the elements.

We then cut to a wide view of the chemical reaction (below) in a more progressed state, where additional points of light are igniting a complex chain reaction. This swirling mass of light & matter begins to form the 3D printed object. The entire system performs like the genesis of a galaxy…



The Nebula: For the second shot, Fusion created a complex, multi-element particle system that consisted of 12 elements and more than 300 million particles. The main swirling nebula is made of 10 krakatoa elements, and there's a murky blue background element and an "ambient" sparse element of bright, but tiny, light points. For the main nebula we created a RealFlow particle system similar to shot 1, but in this case we generated trailing particles for a set of leading points arranged in a circular pattern initially, which then converge to the center. Here's a preview movie showing just the RealFlow particles for the sim we used for the spot :

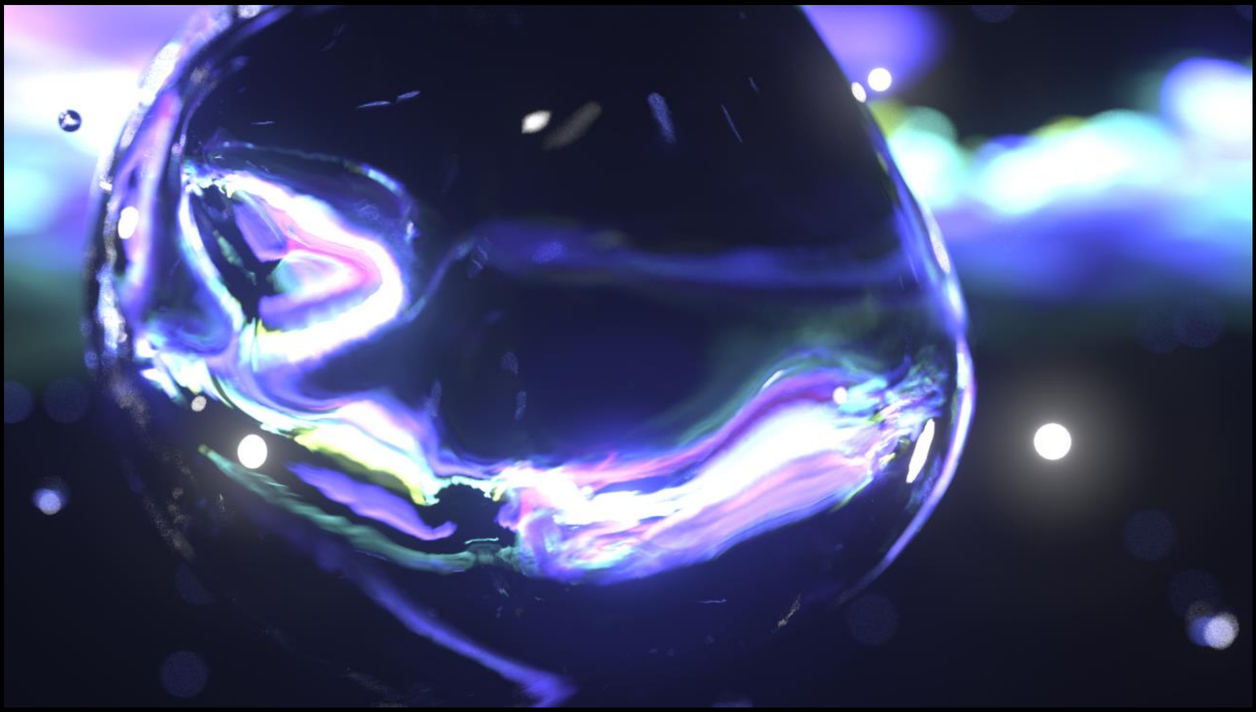
These "thread" sims are very interesting, as they can generate beautiful masses of trails. Here's a preview from an early test of the method where we have irregularly moving lead points generating trails.

From each particle set out of RealFlow, we generated different characters of swirly Fumefx sims. Some elements were more rapidly moving and dispersing, others slower and more concentrated on their sources. We then varied the density slicing settings when generating Krakatoa particles, and in the render different elements got assigned different color variations with age based on the approved color palette. The overall effect gave the final compound nebula element a layered, organic feel. Here's a render of a variation of the element from a static cam, which we did for an internal project called "Genesis" inspired by this project:

Moving in toward the center at the end of the shot, we see that at the central-point reaction is the fluid is building into something, accumulating the fluid material that will form the printer's 3D object….

See Nebula forming

The Droplet: In this shot, a RealFlow simulation of droplets converge. All at high fps, rendered with shallow depth of field and some simulens lens flaring. A key to rendering transparent liquids is reflecting and refracting the environment and since this liquid is coalescing at the center of our swirling nebula, we surrounded the droplet with the nebula. We rendered the nebula element from a central camera with a wide field of view, and then projecting the render as an animated texture on the inside of a cylinder surrounding the droplet.

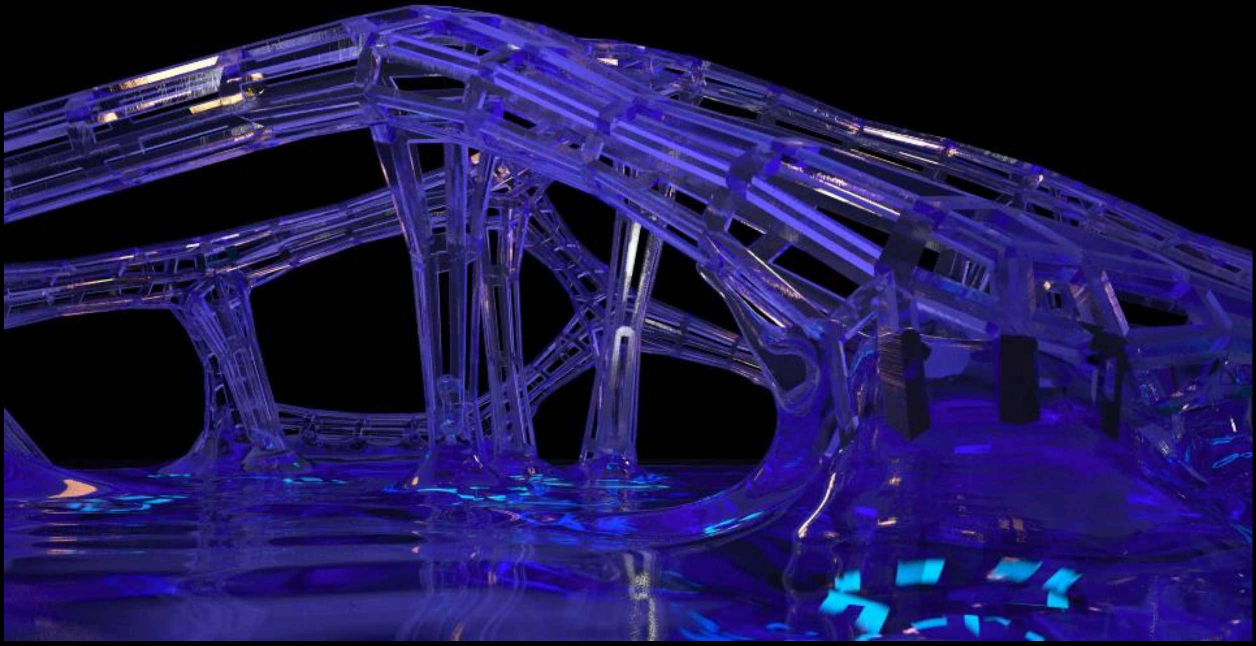


[See Droplet]

In the next shot, the camera was to rise up from below the surface, but it turned out that the transition from the subsurface nebular world to the above surface world was challenging to achieve within the schedule. So for final, it was decided to cut to the surface of the liquid and show just the formation of the 3D buckyball. Everyone at Fusion was of course very sad-faced about this as we'd worked up a cool nebula render and above that the fluid surface reflecting the nebula. We've all been down that road tho, where a shot just doesn't quite pan out as you'd like and it gets omitted. That's the fun of a Case Study! So here's that below-fluid-surface render that did not make the cut.

Above Surface Shots: Buckyball 'Printing'

Buckyball Rising: From here on, we watch in close-up as the buckyball rises from the resin, forming just below the surface in a light-driven interaction. Here's an example of one of the beauty pass renders…



Buckyball Rising

The challenge here was to make it feel like the buckyball was not just rising out of fluid, but actually forming from an illuminated zone just below the fluid surface. This presented a few challenges.

First, the RealFlow fluid simulation. We couldn't in any straightforward way morph the fluid to the shape progressively, as the printer does in reality. This would be a challenging morph to pull off (Fusion has done more than its share of fluid morphing, so we know what's going to be difficult). Second, to get the crisp, sharp edges well defined on the object shape would require a very high res fluid. On top of those challenges, most of the shots showing the liquid / object interaction are extreme close-ups and fairly long shots, which means the sim will have to stand up to close scrutiny. So we opted for a simpler approach of having the object simply rising thru a shallow bath of viscous liquid, and making it feel like it was forming from the liquid thru shading, lighting and compositing.

The simulation itself was conceptually simple, but not so simple to execute. The complex object shape gave the liquid a huge number of little upward "cupped" spots to get stuck in. This went contrary to the creative, where any excess fluid had to slip off the object just a little above the surface. We created a scripted forcefield we called "the cleaner", which applied only to particles touching the geo and above the liquid surface level. The cleaner pushed particles parallel to their colliding face, in a direction as parallel to vertically downward as possible. This gave the fluid a slightly lively movement as it flowed off the object, which when tuned up in terms of strength turned out to be quite similar to the unique sort of motion of the excess resin in the actual printing process. To guarantee continuity and consistency, we ran a single simulation covering the entire animation of the rising object.

Here are preview movies of two of the shots, showing the meshed sim and the behavior of "the cleaner" in action

Preview 1   Preview 2

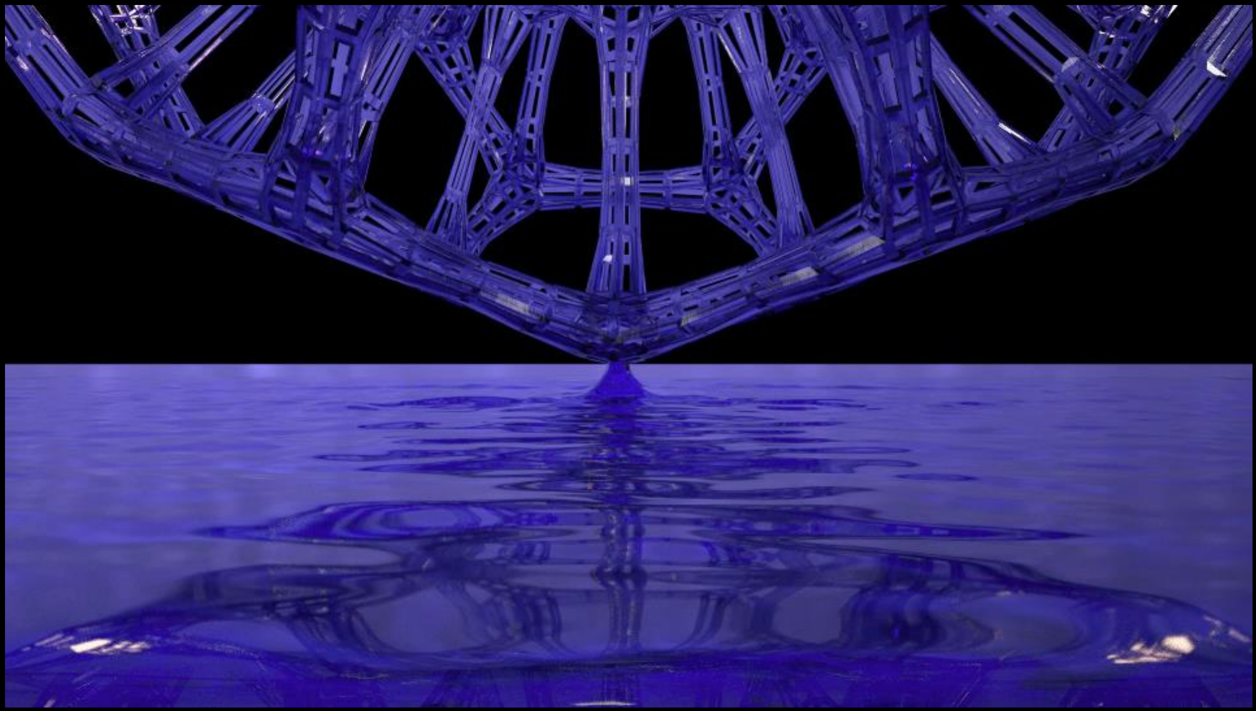
To make it look like the object was being created from the liquid, we made the shader on both liquid and object the same so they'd "melt" together as much as possible in the render. In the composite, the edge between the two was also blurred a little to help with that illusion.

The object itself was rendered with a vertical gradient in opacity, so it appears from nothing within the liquid. In the same vicinity where the object starts to appear, we render a copy of the object but with an opacity map set so it is only visible in the area of formation. This copy of the object has a light-emitting material applied, so it creates the internal illumination near the liquid surface representing (in the real thing) the laser pattern that's triggering the solidification reaction in the resin.

Here's the shot 6 beauty pass, which shows the internal illumination and opacity gradients on the object and light-emitting object:

The down side of internally illuminating the liquid was the render time. Render times with Maxwell increase by a factor of 2-3x if you put lights inside transparent or translucent materials. This was the main reason we did not render depth of field blur, instead rendering a depth pass so depth of field could be handled in comp. Maxwell renders beautiful and very realistic depth of field blur, but to make it look smooth you have to go to quite high SL (sampling level). That combined with the internal illumination of the liquid meant high render times of 8 to 10 hours per frame, and with the spot more than 1440 frames long, we had to be conservative about settings. In the end, we put the emphasis on the important creative aspect of the internal illumination rather than achieving accurate depth of field blur, and then rendered to the highest SL we could in the time available. The beauty pass renders have some noticeable noise in the speculars, but we think the imagery turned out to be mesmerizingly beautiful. Check out the final shot, after the buckyball leaves the RealFlow resin bath and is fully formed.

Thanks again to the incredibly talented team at Cinco Design for the outstanding teamwork!



Final Shot

Finished Piece