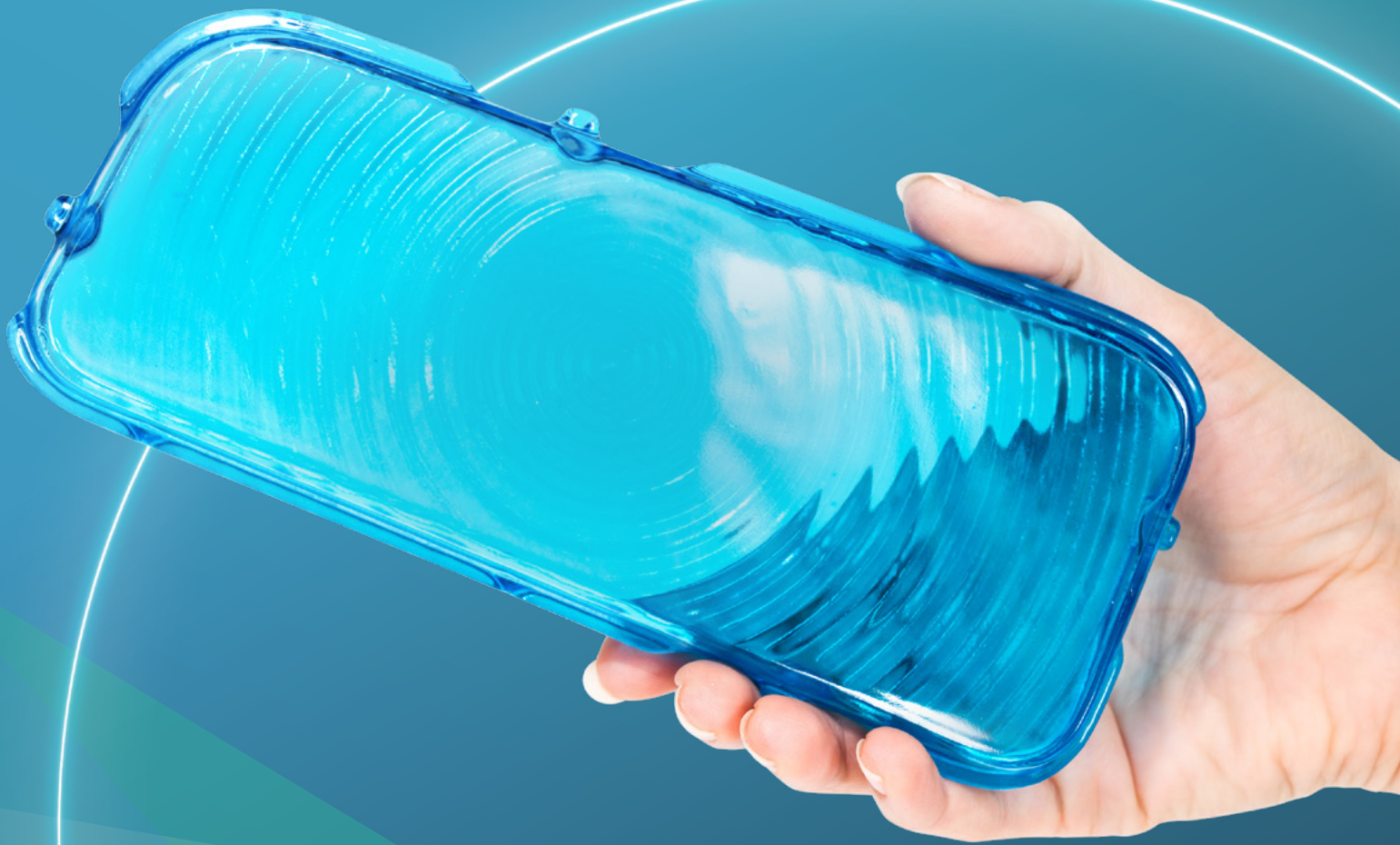
White Paper

Clear 3D Printed Prototypes: A New Sophistication in Rapid Design Testing and Iteration



3D SYSTEMS
Additive Manufacturing Solutions

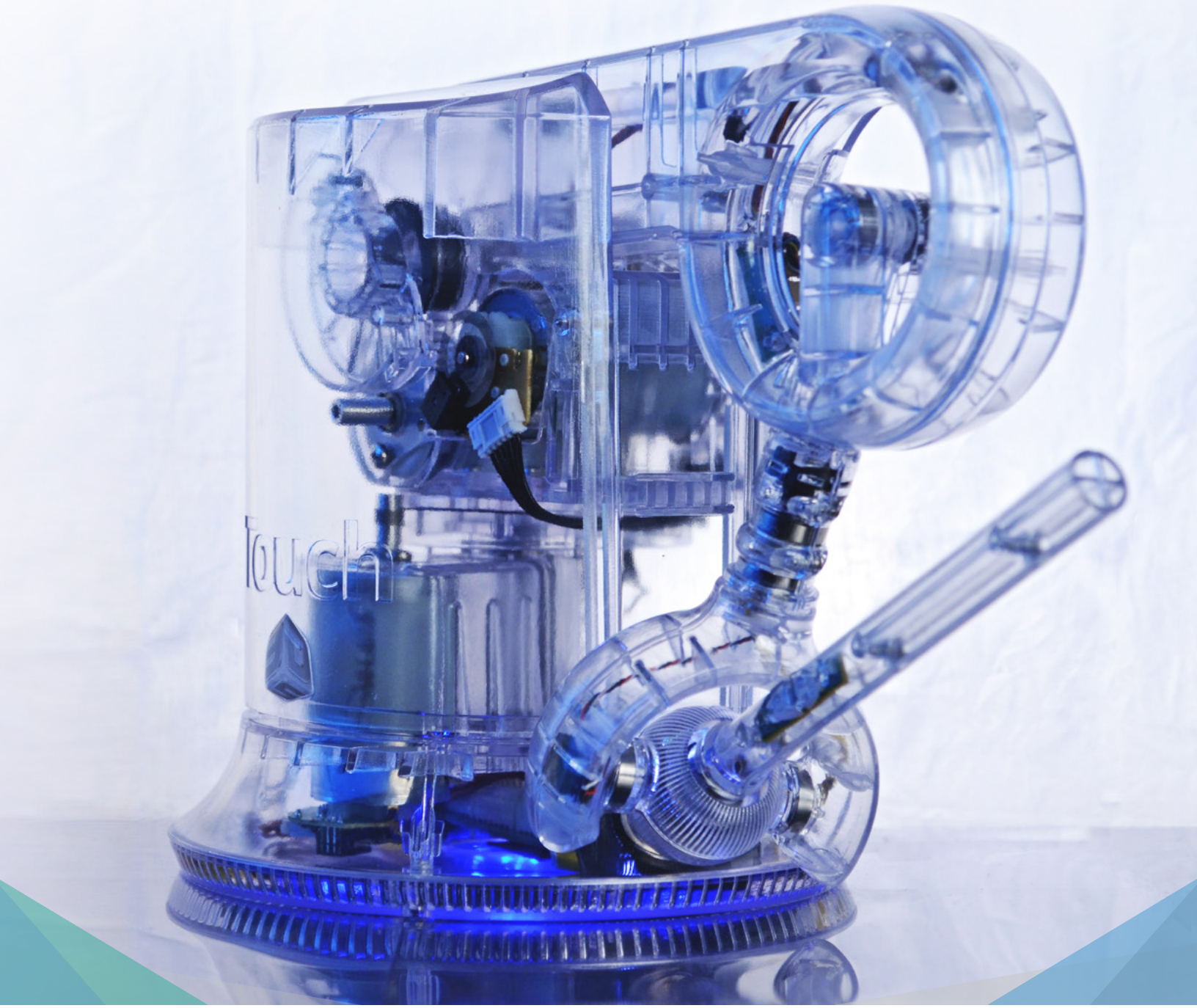
Removing the traditional constraints for prototyping

Manufacturers across the globe have adopted clear 3D printed prototypes to deliver better products, faster. The use of clear materials in prototyping has changed the way designers approach designs for lights, headlamps, reflectors and packaging items such as bottles, as well as delivered enhanced visibility into on-track engine tests and other fluid dynamics verifications.

3D printing, or additive manufacturing, was invented by 3D Systems more than 35 years ago and works by applying materials layer-by-layer to a shape based on the 3D CAD data supplied. This enables new parts that are no longer limited to the restrictions of traditional manufacturing including undercuts, internal geometries and draft angles, but also are not subject to waiting for injection mold tooling nor minimum order quantity (MOQ) constraints.

3D Systems has a range of material options and additive manufacturing platforms that relate to the needs and requirements of any manufacturer. 3D Systems also offers a global on-demand production service that enables engineers to experience the benefits of clear prototyped parts without the capital expenditure in the technologies.

This brief will introduce you to a series of applications, examples and benefits of clear 3D printed parts that 3D Systems offers to meet your specific application needs.



The advantages are clear

3D printed transparent materials deliver an array of advantages to product designers and engineers so that they can 'see' inside a prototype to perform testing.

This methodology delivers far greater insight into how a part or assembly will operate in the real world. The rapid production of prototypes for this kind of testing enables those insights, and resulting design changes, to be made far more quickly.

This delivers business benefits including:

- Higher quality parts and assemblies
- Lower tooling costs
- Innovation for more complex parts
- Quicker design iterations
- Design cycle compression
- Reduced cost of prototyping and testing
- Problem avoidance during production ramp-up
- Significantly faster part-time-to market with more confidence

Transparently superior additive materials

The range of clear materials from 3D Systems deliver options for printed parts that have high thermal and moisture resistance and are robust and strong. The clear materials available have properties such as glass-like clarity and emulate polycarbonate, acrylic and polystyrene materials used in traditional manufacturing.

While the clear materials offer top-level transparency they are also straightforward to tint and dye to deliver realism in certain applications.

This enables our customers to perform the following functions:

- On-car testing for fluid flow
- Functional testing of clear air filter parts to determine air flow and filter functionality
- Clear housings around an assembly to perform interference checks
- Testing of reflectors and lens designs for clarity, direction and focus of the light beam
- Creation of custom jigs and fixtures that need a clear view into the part being assembled
- Creation of anatomical models that need selective colorization to highlight contained geometries
- Prototyping of light pipes and IR sensor packing
- Production of custom drill guides for surgery and dentistry
- Production of prototype packaging such as bottles for look, feel, adherence to brand and aesthetics

IN A CLASS OF ITS OWN

3D Systems' Accura® ClearVue SLA transparent material has been proved in laboratory testing to be the clearest (closest to the transparency of water) additive material available in the industry. With a light transmission measurement of 95.45, this material can deliver significant benefits where almost perfect transparency is required.

SMOOTHER SURFACES

3D Systems' MultiJet printers (MJP) have shown in comparative testing to have half the surface roughness than that of its closest competitive platforms.

Additive technology that meets your needs

For clear prototyping, 3D Systems delivers two options for technology platform depending on the budget, applications and facility that will be used for the 3D printing projects. These two technologies are Stereolithography (SLA) and MultiJet Printing (MJP).

SLA 3D printing uses photopolymerization to create parts layer by layer in a tank of resin that is cured using directed UV light. As well as being the original 3D printing technology, it is also the most advanced, delivering superior surfacing of parts better than any comparable additive technology.

3D Systems SLA 3D printers range in build sizes from 250 x 250 x 250mm all the way up to 1500 x 750 x 550mm enabling the rapid production of even very large parts. SLA 3D printing delivers high throughput and part detail with the widest range of materials in the industry. SLA 3D printing can require extensive post-processing to remove supports and requires a shop-floor type environment.

3D Systems MJP printing is a robust and mature 3D printing technology with many unique values. In this technology, a high-resolution printhead jets extremely small droplets that allow the creation of very detailed and complex parts and single build assemblies. A wax support material is used that requires no user placement for even the most complex features and is easily removed. The MultiJet (MJP) 3D printer build sizes range from 295 x 211 x 142mm to 518 x 381 x 300mm enabling fast, consistent prototype part production with an affordable price, compact footprint and easy part processing.

The MJP 3D printing platforms can be used in an office environment due to the waste-free changeover option and quick, hands-free swapping of the materials based on daily job requirements.

Extreme ease-of-use is also achieved through the wax supports, which are automatically created regardless of part geometry and its complexity, that are removed easily by simply applying heat. They require less capital expenditure and technical training, and are highly versatile with a range of easily changed materials.

CLASS VI COMPATIBILITY FOR STATE-OF-THE-ART MEDICAL APPLICATIONS

3D Systems has a choice of five Class VI clear materials. This means that medical instruments that require visibility can be easily produced, once cleared, for applications such as dental surgical guides. Anatomical models printed using clear materials that have the ability for selective coloration can deliver new insights for patients and surgeons alike, by highlighting internal anatomy, growths and other anomalies.

SETTING A NEW STANDARD IN 3D PRINTING SOFTWARE

All 3D Systems' SLA and MJP 3D printers are delivered with 3D Sprint additive manufacturing software, tuned to deliver true productivity gains on 3D Systems' plastic printers. Working directly from your CAD data, 3D Sprint prepares and optimizes your 3D designs. With an arsenal of editing, alignment, nesting and print management tools, 3D Sprint enables you to significantly streamline your operation and optimize cost of ownership of your 3D Systems 3D printers.

NO CAPEX BUDGET? NO WORRIES

Investing in industrial 3D printers demands capital expenditure as well as training. Service bureaus can help you experience the advantages of clear prototyped parts without the upfront costs. A service such as 3D Systems On Demand Manufacturing can have a prototype part built, expertly finished and shipped within days of order further enabling rapid iteration in agile manufacturing.

Find out more about On Demand Manufacturing ›

Accura® ClearVue™

Laboratory testing has shown that 3D Systems' Accura ClearVue material is the most transparent in the industry, enabling parts that appear incredibly close to water transparency – the standard in clear materials.

Accura® Phoenix

Thermally resistant, antimony-free, robust transparent plastic with exceptional clarity that improves viewing of hot fluid or air flow in extreme circumstances such as complex automotive parts for under-the-hood testing, as well as viewing of internal parts in an assembly.

On Demand Manufacturing

Just one single On Demand Manufacturing location produces an average of 8,000 clear parts a month for customers worldwide.

Experts in SLA Clear 3D printing and post-processing can make the clear difference to your prototype.

CLEAR PARTS IN THE REAL WORLD:

Clear MJP 3D printed molds deliver for university researchers

Kevin Nelson, a researcher in the Department of Electrical and Computer Engineering at the University of Florida, had a challenge – while trying to develop sensors for underwater vehicles to emulate the sensory capabilities of fish, he knew he needed a new way to produce the sensors so they would operate perfectly under water.

To achieve success the sensor modules needed an almost perfect surface finish, and the sensors inside needed to be in the perfect position. To tackle this, Nelson opted for custom molds 3D printed on the MJP 2500 3D printer using VisiJet M2R-CL clear materials.

Said Nelson, "The clear material facilitated the sensor manufacturing process, allowing us to position the sensor board in each mold within the desired tolerances. In addition, we were able to ensure that the board didn't move during the elastomer pouring phase and that the desired volume of elastomer was poured into each mold. The near perfect surface finish of these 3D printed molds enabled the finished modules to have a desirable hydrodynamic profile."

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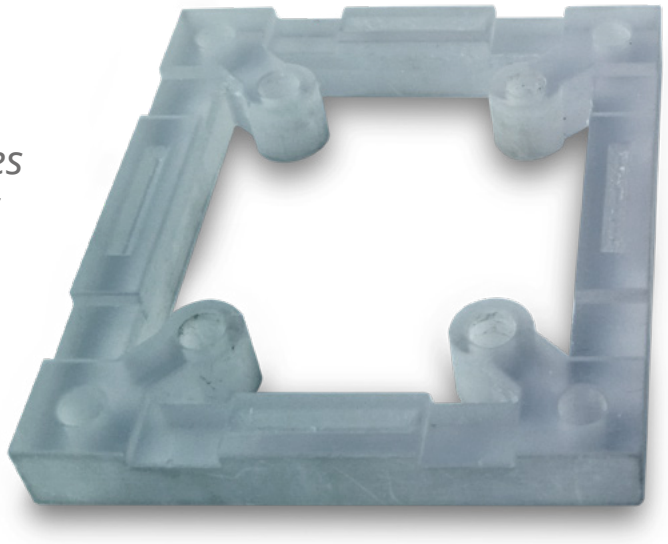


CLEAR PARTS IN THE REAL WORLD:

Orora uses clear 3D printing to deliver realistic bottle prototypes for in-store testing

Before making the investment to overhaul its glass bottle tooling systems, the maker of Australia's James Boag Premium Lager needed to know that a bottle update would align with their brand architecture and be appealing to their customers. It needed to be sure the new bottle would look good and be well received by customers. Ideally, this confidence would come before spending major time and capital on the project.

Packaging designers at Orora worked with the 3D Systems On Demand Manufacturing (ODM) team in Australia to deliver realistic 3D printed bottle designs using 3D Systems' SLA 3D printer and VisiJet Clear materials.

To be convincing, the 3D printed models needed to have the same clarity and hue as glass as well as the same in-hand heft. The ODM expert team accounted for weight disparities by adjusting the interior wall thickness of the design file based on the density of the selected stereolithography (SLA) resin.

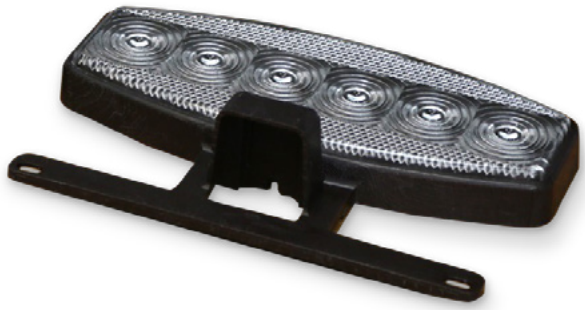
They then got to work on color-matching to achieve the iconic green of the classic Boag bottle.

The appearance models were ready within a week, allowing Orora and Boag to quickly transition the new design to customer trials and gauge the public's reaction. They filled the 3D printed bottles with liquid, outfitted them with a label and cap, and put them in a shop for monitoring. Feedback from these in-store trials indicated that the new design was a hit, clearing the new design for production.

CLEAR PARTS IN THE REAL WORLD:

TecNiq improves product development with clear 3D printed lenses

TecNiq, a leading provider of LED lighting solutions, uses its own software to deliver billions of calculations that create the optimal balance between LED energy efficiency, lighting performance and cost. With the addition of a 3D Systems ProJet 6000 SLA 3D printer to its operation in 2015, the company is moving to new heights in productivity and business growth: On the engineering side TecNiq has developed more efficient methods of manufacturing and assembling plastic lenses while reducing tooling errors. On the business side it enabled TecNiq to attract new clients and retain existing ones.



Using the SLA 3D printer and VisiJet® SL Clear material the company has shifted its lens prototyping from direct machining in plastics to 3D printing to deliver superior prototypes, faster. With a lacquer clear coat on the printed lenses, TecNiq was able to match the surface quality of its manufactured products.

With the added ability to test snap features and make rapid changes to the designs, the company has avoided potential tooling problems and the cost associated with that. In addition, the company believes that having prototypes that conform to the look, feel and performance of a final product is invaluable for their customers and their business growth.

CLEAR PARTS IN THE REAL WORLD:

CIDEAS delivers the expertise for customers in 3D printed clear parts

CIDEAS is a 3D printing service bureau in suburban Chicago with an international following and a visible expertise in many kinds of 3D printing including high-quality clear printed parts using 3D Systems SLA 3D printers and Accura® ClearVue material.

An early use of Accura ClearVue by the CIDEAS team was for patient-specific models of the heart and connecting aortic branches, which surgeons use to prepare for surgery. Other common projects include lenses, light pipes, IR sensor packing, and packaging displays.

One client creates prototypes of conformal cooling molds, while another creates point-of-sale displays for retail products or executive review.

Using in-house processes, CIDEAS can start with Accura ClearVue and then match to a specific tint such as red or amber typically used in automotive tail lights as required or supply the part as frosted. This team's post-processing skill with ClearVue has gained CIDEAS clients in the lighting industry, who create prototypes of frosted diffused lighting products that rival the final production glass.

CLEAR PARTS IN THE REAL WORLD:

3D Systems On Demand Manufacturing service for clear parts

With twelve production facilities worldwide and decades of combined experience, 3D Systems' On Demand Manufacturing service produces a lot of 3D printed parts. One of its locations in Lawrenceburg, TN, produces an average of 8,000 clear parts per month, using the range of SLA 3D printers from 3D Systems.

One of the keys to success with clear printed parts is having the expertise and set up to finish the parts well – from sanding through to tinting, to clear coat finishing.

Find out more about On Demand Manufacturing ›

"Given our history and expertise, we know that On Demand Manufacturing delivers truly world-class results in SLA, especially Clear Parts, Our latest QuickParts e-commerce service also enables you to get prototypes in even faster time."

- Tracy Beard, general manager at the Lawrenceburg facility

KNOW THE DETAILS:

Clear Materials for SLA 3D printing

SLA 3D printing delivers industrial-grade batch 3D printing with superior surface finish on parts. There are five clear materials for SLA 3D printing each with unique properties for specific applications.

Accura ClearVue materials have been proved in laboratory testing to be the industry's clearest 3D printing material available, outperforming competitors as much as 7% in clarity, with up to 500% less green tint and 400% less yellow. With this superior clarity, the material, along with VisiJet SL Clear, delivers rigid and tough clear parts, and excellent humidity and moisture resistance. Ideal use is in the prototyping of headlamps, lenses and bottles, and it is capable of meeting Class VI requirements for use in some medical arenas. Accura ClearVue Free delivers an antimony-free alternative to Accura ClearVue, often used for prototypes using snap-fits and in need of functional testing.

Accura 60 is a high-rigidity clear material with outstanding productivity. Ideal prototypes for this material include, light pipes, and applications where extreme precision is required.

Accura Phoenix delivers prototypes that will be used in high thermal conditions over 120°C. It is typically used for engine oil flow testing and high heat applications such as jigs and fixtures that require clarity.

Accura SL Y-C 9300 enables selective colorization of the parts to highlight contained geometries. As a Class VI capable material, this has been used extensively in anatomical models for healthcare applications to enable surgeons to understand unique patient anatomy.

MATERIAL	DISTINGUISHING PROPERTIES	APPLICATIONS	CERTIFIED PRINTERS[1]
Accura® ClearVue[2] & VisiJet® SL Clear[2]	Unbeatable clarity; rigid and tough; excellent humidity and moisture resistance	• Lenses • Headlamps • Consumer packaging • Applications that require transparency or clarity to match glass, polycarbonate, acrylic etc.	For Accura ClearVue: • ProX® 800 • ProX® 950 For VisiJet SL Clear: • ProJet® 6000 • ProJet® 7000
Accura ClearVue Free	Clear material with a bit of flex; tough; excellent humidity and moisture resistance	• Snap fits • Functional prototypes	• ProJet® 800 • ProJet® 950
Accura 60	High rigidity clear material; high accuracy with rapid build times; reasonably high heat deflection (48°C at 66 PSI; 41°C at 264 PSI)	• Thermoforming • Light pipes • Applications where extremely high accuracy is required	• ProJet® 800 • ProJet® 950
Accura Phoenix	Clear material with the potential for high thermal resistance[3] over 120°C	• Engine oil flow visualizations • High heat applications that require clarity	• ProJet® 800 • ProJet® 950 • ProJet® 6000 • ProJet® 7000
Accura SL Y0C 9300[2]	Clear material suitable for selective colorization to highlight contained geometries	• Anatomical models in healthcare • Visualization within parts	• ProJet® 800

[1] Indicates printers for which a given material has been proven through testing; unlisted printers may still support related materials without full certification.
[2] Indicated Class VI capable
[3] Additional high temperature materials with various secondary properties and levels of clarity are also available. Thermal post-cure slightly alters color.

KNOW THE DETAILS:

Clear materials for MJP 3D Printing

The ProJet MJP 2500 3D printer is designed to be used by an individual user up to a large group and offers numerous materials for a wide variety of customer needs.

One unique aspect of the ProJet MJP 2500 is that four different clear materials are available for the printer, spanning a wide range of material properties from strong and rigid to tough and flexible. These clear materials achieve very high optical clarity and visual quality and are ideal for all aspects of the design cycle including concept models, functional prototyping, jig and fixture development, and small volume early manufacturing needs.

VisiJet® M2R-CL rigid clear material can be used to achieve excellent optical clarity. This material has relatively higher stiffness, strength and heat deflection temperature compared to the engineering clear materials.

The VisiJet M2R-CL rigid clear is a strong and stiff material with tensile strength 35-45 MPa, an elastic modulus of up to 2000 MPa and yet still achieves an elongation at break of up to 30% and an as-printed heat deflection temperature of 51oC. This material is capable of achieving USP Class VI requirements for some medical uses.

The engineering materials VisiJet Armor (M2G-CL) and VisiJet ProFlex (M2G-DUR) maintain the high quality of MJP, but were designed specifically for the most aggressive engineering applications including high impact applications, complex snap fits, and living hinges. The VisiJet Armor material is an engineering clear material that has a very good balance of stiffness and toughness.

The VisiJet Armor material is designed to have ABS-like properties to simulate injection-molded plastic parts. VisiJet Armor has an impact strength of 40-50 J/m, and yet still maintains a tensile strength of 30-35 MPa and an elastic modulus of up to 1500-2000 MPa and elongation at break between 55 to 65%.

VisiJet ProFlex material is the most flexible engineering material and has the highest toughness. The VisiJet ProFlex material is designed to have polypropylene-like properties and is extremely flexible and tough making it nearly impossible to break for even the most aggressive applications. VisiJet ProFlex has an impact strength of 70-80 J/m and is much more flexible with an elastic modulus of 250 to 350 MPa and elongation before break up to 75%. All three of these materials are optically clear and can be dyed and tinted, quickly and with a very professional quality.

For the ProJet MJP 5600 3D printer, the VisiJet CR-CL 200 is a rigid clear material with a moderate flex, useful for general prototyping. Since it is capable of achieving USP Class VI, it works very well for medical applications such as custom drill guides.

MATERIAL	DISTINGUISHING PROPERTIES	APPLICATIONS	CERTIFIED PRINTERS[1]
VisiJet Armor (M2G-CL)	Engineering ABS-like material; mid-modulus, tough	• General purpose prototyping • Consumer packaging • Jigs and Fixtures • Housings that need to withstand handling\abuse • Snap fits	ProJet MJP 2500 Plus
VisiJet ProFlex (MRG-DUR)	Engineering Polypropylene-like material; flexible; high impact strength	• Snap fits • Functional prototypes	ProJet MJP 2500 Series
VisitJet M2R-CL[2]	Rigid; moderate flex	• Thermoforming • Light pipes • Applications where extremely high accuracy is required	ProJet MJP 2500 Series
VisiJet CR-CL 200[2]	Rigid; moderate flex	• Engine oil flow visualizations • High heat applications that require clarity	ProJet MJP 5600 Series

[1] Indicates printers for which a given material has been proven through testing; unlisted printers may still support related materials without full certification.
[2] Indicated Class VI capable

Post-processing translucent and tinted parts

All 3D Systems clear materials can be post-processed for exceptional clarity, and tinted for realistic prototypes such as automotive lights or consumer product casings. The process typically requires some dry sanding, spray tint or application of dye, with UV-resistant clear coating for the final overall effect.

The importance of surface smoothness to part clarity can be observed in frosted glass. By altering the surface smoothness of an otherwise transparent material, glass appears opaque. In many cases the clarity of 3D printed clear materials can be improved by sanding and applying a clear over-coating, such as the clear-coat spray cans commonly found in auto parts or hardware stores.

Tinting and clear-coating 3D printed parts allows users to achieve the visual appearance of glass, polycarbonate, and acrylic, or any familiar hue of lighting or housing cover.

Watch our Clear Tinting video now ›

What's Next?

Interested in Learning More About Clear 3D Printed Prototypes?

Talk to an expert about which clear materials and printers would work for you

Get in Touch

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