



Connex3

THE VERSATILITY STANDARD IN 3D PRINTING

By Stratasys

Connex™ 3D Printing advanced additive manufacturing as the first PolyJet™ technology to offer multi-material 3D printing. The Connex3™ 3D Printer, now an industry standard in high-precision, multi-material 3D printing, offers a range of capabilities, from rigid plastic to rubber-like to transparent, giving engineers the ability to print smooth and strong composite materials thanks to Digital ABS *Plus*™.

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Figure 1: The cyan-yellow-white palette produced this hand-mixer prototype.

Connex3 combines three base materials and offers an expansive material selection and rich, vibrant colors. Connex3 technology is available in three build tray sizes and supports any three materials from the five base colors — white, black, cyan, magenta and yellow — as well as hundreds of Digital Material™ combinations. The striking blended color palettes and versatile material combinations make it possible to print realistic prototypes with speed and accuracy.

Connex3 3D printed parts perform well both visually and functionally. The product realism and enhanced functionality bring complex parts to life, satisfying the artist, designer, engineer and product manager. Manufacturing engineers

are pleased with Connex3's rugged Digital ABS *Plus* output for areas like injection molding and functional parts. And thanks to its superior versatility, Connex3 is the technology for end-to-end prototyping needs for every stage of product development.

ADVANCED RAPID PROTOTYPING

Connex3 can build as many as 82 material characteristics into an individual part, assembly or multi-part job. The wide range of material properties, colors and opacities create ready-to-use models ideal for rapid prototyping, because it eliminates secondary operations such as assembly and painting, all while delivering



Figure 2: This functional propeller cone assembly in Digital ABS *Plus* features smooth, cone-shaped surfaces and bolt assemblies.

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the speed, precision and resolution of PolyJet technology. Prototypes featuring smooth, curved surfaces with minimal 'stepping' effect are enabled by 16-micron layer printing.

SIMULATE COMPLEX, FINISHED PRODUCTS

Nidek Technologies (Nidek), an ophthalmological device manufacturer, found the Connex3 optimized their rapid prototyping process, and as a result, accelerated the clinical validation of their ophthalmological diagnostic systems. All of Nidek's products have direct contact with patients, so it's crucial to produce fully-functional prototypes that precisely replicate the final product. The Connex3 enables Nidek to perform a comprehensive evaluation of fit, form and function



Figure 3: The external case of Nidek's prototype Gonioscope® was built on a Connex3 3D Printer.

before moving to final production, significantly cutting the time it takes to get the products to market.

Cesare Tanassi, CEO at Nidek, stated their prototyping process has become much more streamlined since incorporating the Connex3 into the workflow. "The ability to quickly 3D print high-quality parts that require no post-processing has proven instrumental in cutting our iterations, and directly reducing our product development cycle. In fact, we have slashed our prototyping costs by 75% and accelerated our development time by 50%," said Tanassi.

PRODUCT DESIGN PROFICIENCY

At Boston University, engineering students, enabled by the multi-material, multi-color capabilities of the Connex3 on campus, gain valuable product development experience by prototyping for local area businesses. Students have helped improve highly niche products such as air quality monitors by creating realistic, fully-functional prototypes on a Connex3.

The results of the class have empowered students, and yielded innovative designs. "When you give

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“When undergraduate students have professional tools, they achieve professional results. We want them to be great professional engineers, and the sooner we give them professional tools, the sooner they achieve that goal,” said Gerry Fine, an engineering professor at Boston University.



Figure 4: The Connex3 prints functional prototypes and ready-to-use models in an array of eye-popping colors.

SUPERIOR PRECISION, DURABILITY FOR COMPLEX APPLICATIONS

The Connex3 gives users the ability to evaluate form, fit and function by 3D printing strong, durable parts in Digital ABS *Plus*. The highly

accurate parts have an impact resistance of up to 110J/m (1.69 – 2.06 ft lb/in). These are not only suitable for design validation, but also provide an additional step to functional performance testing when material mechanical properties are essential to final validation and design approval.



Figure 5: This hand-powered drill features moving gears, screw-fits, pressure inserts for handles and moving parts. Complex geometries, interlocking gears and functional use parts are made possible by the accuracy and tolerance Digital ABS *Plus*.



Figure 6: This flexible motor shaft coupler demonstrates the ability of Digital ABS *Plus* to allow end movement without breaking. Small metal clips are attached to jig base.

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The toughness of the Digital ABS *Plus* material makes it ideal for prototypes and parts featuring repeated flexing and bending, such as clips and fasteners.

TOOLING

Digital ABS *Plus* can also meet the challenge of short-run injection molding applications.

Turck, a leader in industrial control solutions for factory and off-road equipment, offers hundreds of overmolded products for custom applications, and leans heavily on their Connex3 to meet the challenges of their industry.

“The challenge was finding a 3D printing technology strong enough to hold up to short injection molding runs,” said Florinel Ciubotaru, Turck senior project manager.

Digital ABS *Plus* on the Connex3 met Turck’s challenge. With the technology in house, Turck produces prototypes for overmolded products in just a few days after completing the design, and Ciubotaru adds, “Digital ABS provides high-temperature resistance, toughness and rigidity, which are just what we needed for this application.”



Figure 7: Digital ABS *Plus* on the Connex3 builds tough injection molds fast for Turck.

The ability to blend Digital ABS *Plus* with rubber-like Digital Materials on the Connex3 also makes it a beneficial option for improving production. That material flexibility allows users to optimize and customize manufacturing aids for specific tasks, components, individuals or equipment, such as assembly devices that require durable rubber-like grips.

COLOR

While multi-color 3D printing isn’t new, it is uncommon. What sets Connex3 apart are the qualities users report that make Connex3 parts look just like their injection-molded counterparts. The Connex3 is capable of printing color in plastics that are strong, smooth and can

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accommodate fine features. The model material contains the color, which results in great vibrancy. Unlike other technologies, Connex3 does not rely on saturating a base material with “ink.” Colors in parts printed on the Connex3 are consistent and predictable from job to job, and the entire part contains color, not just the outer surfaces. The Connex3 can mix one or two base colors with a clear material, giving the user a range of translucency to print items such as tinted lenses and bottles. The Connex3 can also print rubber-like Digital Materials in a wide range of colors and Shore A values.

PROPERTIES

The ability to use three base materials simultaneously expands both the number of materials available and the number of combinations in an individual part.

Material and Color Combinations

Connex3 combines Digital Materials with a third choice: color, clear or rubber-like. Since Digital Materials like Digital ABS *Plus* are a blend of two materials, only 3D printers based on a triple-jetting platform can do this.



Figure 8: Connex3 allows for blending color and clear for translucent lenses.

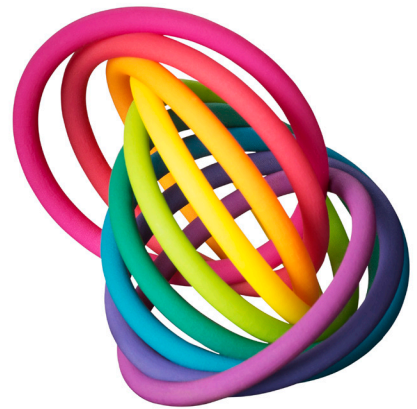


Figure 9: These interlocking color rings were 3D printed in one job using the cyan-magenta-yellow palette.



Figure 10: The Connex3 3D printed this colorful, flexible keyboard in one job by combining clear rubber-like material with magenta.

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With the third material, Connex3 can 3D print parts using Digital ABS *Plus* (or another Digital Material) plus one other, dissimilar material. Rubber overmolded parts with Digital ABS *Plus* are possible, or the third material means Digital ABS *Plus* can be combined with color accents or clear features.

Digital ABS *Plus* Strength Plus Flexibility

Connex3 provides the capability of not only using three materials in the same part, but also creating composite materials from three base resins. Users are able to blend the strength of Digital ABS *Plus* and also achieve a range of Shore A values into one component.



Figure 11: This electronic device uses Agilus30 for the rubber-like, over-molded anti-slip surfaces. The battery compartment cover features functional snap-fit clips.

Several Digital Materials blend Digital ABS *Plus* with rubber-like materials for a hardness range from Shore A 27 to Shore A 95. These materials are especially useful in applications needing non-scratch surfaces and strong rubber-like grips, such as prototypes for surgical devices.



Figure 12: This surgical prototype also features Digital ABS *Plus* and black Agilus30 overmolding for superior grip, and a 3D printed color handle, printed separately.

HOW IT WORKS

The concept is simple; the technology is not. Connex3 uses a print block containing eight print heads: two for each material, including supports. This leaves six print heads for three model materials. The print heads deposit material droplets in a pre-defined pattern to create combinations from as many as three base materials. Those patterns yield Digital Materials, which are more than a simple blending of base materials.

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The Rigid Palettes

As with 2D printing, users load a combination of colors from CMYK, which stand for cyan, magenta, yellow and black. When desired, users can swap in white or clear. Because Connex3 supports three base materials, users have the option of using any three of the following: VeroCyan™, VeroMagenta™, VeroYellow™, VeroBlackPlus™, VeroWhitePlus™ or Vero PureWhite™, and VeroClear™. These combinations created 14 original color palettes, each with 45 or 46 hues.

The Flexible Palettes

Users load either TangoBlackPlus™ or TangoPlus™, and then have the option of using any two of the following: VeroCyan, VeroMagenta and VeroYellow. With TangoPlus, users select from 82-color palettes, which feature a wide selection of Shore A values. With TangoBlackPlus, users select from three 76-color palettes, also with a range of Shore A values.

Users select from combinations of rigid and rubber-like materials to produce Digital Materials with a wide range of properties. A single part could have, for example, a sturdy Digital ABS *Plus* structure with a soft-touch rubber overmolding.

The Workflow

The lifeblood of 3D printing, the STL, contains no information on properties. So we recommend creating a CAD model as a multi-bodied assembly and export as separate STLs. Create the individual bodies, or “shells,” with an interference fit, since overlaps create unpredictable blends of Digital Materials and gaps will cause the part to separate.

A shell is required for each color or material. In Objet Studio™ software, users separate the assembly into its discrete shells and assign a material or color for each. To do this, users select the three base resins to load in the Connex3. The software calculates the resulting Digital Material options and provides a dropdown palette each time the user clicks on a shell.

Connex3 supports STLs and files exported from CAD in VRML format, as an alternative to STL. VRML improves the user experience in several ways: it retains color designations the designer made in CAD, or uses an optional closest match algorithm; it vastly improves workflow by eliminating the need for the operator to designate a color for each shell; and it provides Connex3's 10 Rigid Opaque color palettes directly in SolidWorks or Rhino.

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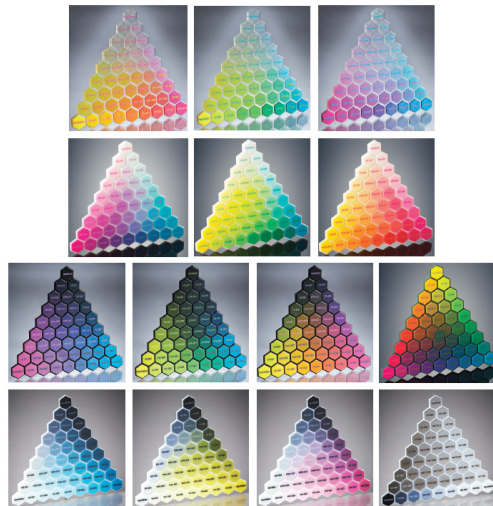


Figure 13: These 14 color palettes represent the color-blending capabilities of the Connex3. Each side and interior cell is a specially engineered Digital Material.

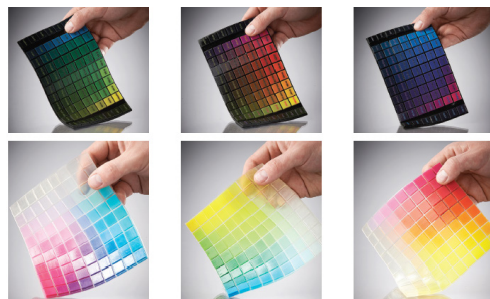


Figure 14: These six flexible color palettes provide a range of color options and Shore A values. Three 82-color palettes feature combinations of TangoPlus with VeroCyan, VeroMagenta and VeroYellow, while three 68-color palettes combine those same vivid colors with TangoBlackPlus.

A notable workflow advantage with Connex3 is the flexibility to choose between two support material options based on whether:

- Your design requires delicate features or convoluted voids (SUP706 soluble support)
- Automation is important (SUP706 soluble support)

- Turnaround time is your ultimate priority (WaterJet removable support)

SUP706 is hands-free and ideal for cleaning complex geometries such as tunnels and holes or small, delicate parts that cannot withstand WaterJet pressure. This is another way Connex3 provides flexibility to accomplish diverse tasks with one system.

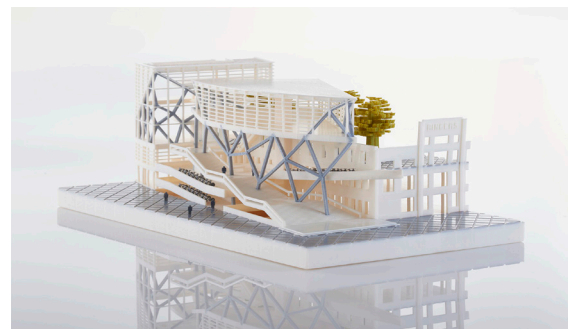


Figure 15: This architectural model was printed with Vero PureWhite using SUP706 soluble support.

Color Range

In 2D color printing, four base colors are mixed, and the paper adds a fifth color. That's how a million hues are possible.

With a three-color system, Connex3 users select a palette for each color print run, each providing 45 to 82 color options.

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Colors are consistent, and Stratasys has matched them with corresponding hex and RGB values for convenience and reliability.

Vibrancy

Connex3 has two modes: glossy and matte finishes. As with any colored object, a glossy finish brings out the brilliance and vibrancy. That is why Stratasys recommends the glossy mode.

TECHNIQUES

Users of Connex3 have been working on techniques to maximize the capabilities. To jump-start a multi-color, multi-material 3D printing operation, here are some of their recommendations.

Workflow

Post a guide to Digital Materials to make color and property selection easy. Make it clear that there are specific material combinations offering reliable color and material-property options.

When providing work instructions to a Connex3 technician, supply a marked-up drawing or illustration that identifies the Digital Material and color assignments. This becomes the work detail when processing files in Objet Studio.

Another tip is to make the team aware of which palette will be used in the next print run. This can minimize material changeovers by aggregating parts using the same palette. Remember that even building single-material models can happen efficiently with Connex3, because you can combine diverse models that together require up to three base resins and their resulting Digital Materials, all into one job.



Figure 16: This 3D printed prototype was built in one job with rigid cyan, rigid magenta and black rubber-like materials, offering a range of as many as 68 colors and dark shades from blue to purple to magenta, plus flexible rubber-like components in black.

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Digital Model

When aesthetics are of utmost importance, maximize glossy mode by minimizing support material. Split the model so that all pieces avoid support material on cosmetic surfaces. Print each with a glossy finish. After printing, join the parts.

Overlay Shell

Add color to Digital ABS *Plus* and rubber-like parts by overlaying a thin shell of opaque or translucent color. To add a layer of color over Digital ABS *Plus*, create a separate surface in CAD, which becomes a shell that can use one of the Vero colors. In the CAD model, create an overlaying body that will be the exterior surface of the feature that receives color. Make this skin approximately 1.5 to 3 mm (0.06 to 0.12 in) thick for best appearance. In Objet Studio, apply the desired color to this shell.

Transitions and Textures

When needed for lifelike product appearance, combine Connex3 with a bit of post-print decorating. Treat Connex3 color as the base and add soft fades or textures with a little air brushing.

Conclusion

Connex3 technology is one of the most versatile and powerful rapid prototyping solutions available. It provides realistic multi-material 3D-printed parts without sacrificing speed, resolution or layer thickness. The Connex3 covers a very wide and deep range of applications and industries, featuring advanced capabilities for companies that need to focus on the design verification stage of rapid prototyping. This means accurately simulating their final product using color, rigid, rubber, transparent and tough functional materials together. With these capabilities all possible in one system — Connex3 is the industry standard in rapid prototyping.

Solutions such as the Connex3 do not remain static. We are constantly working to add new and groundbreaking advancements to the already unrivaled capabilities it offers, including new materials that will continue to push the boundaries and offer solutions for all rapid prototyping use cases in functional performance, design verification and concept modeling.



STRATASYS.COM

HEADQUARTERS

7665 Commerce Way, Eden Prairie, MN 55344

+1 800 801 6491 (US Toll Free)

+1 952 937 3000 (Intl)

+1 952 937 0070 (Fax)

2 Holtzman St., Science Park, PO Box 2496

Rehovot 76124, Israel

+972 74 745 4000

+972 74 745 5000 (Fax)

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