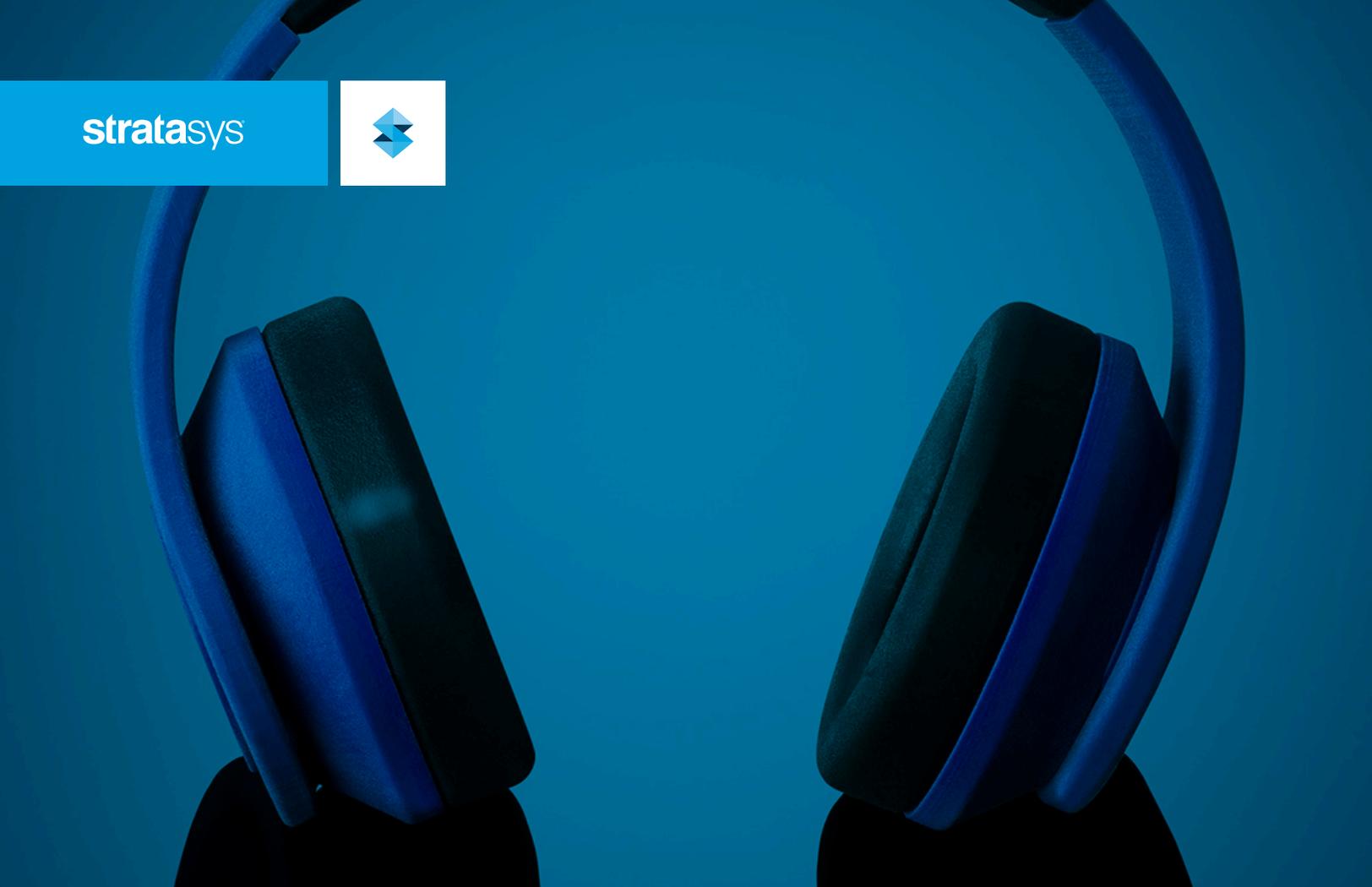


stratasysTwo 3D printed parts, possibly brackets or connectors, are shown against a blue background. The parts are dark blue with lighter blue accents, demonstrating multi-material printing. They are positioned symmetrically, one on the left and one on the right, with a circular blue ring above them.

Connex3

THE NEW VERSATILITY STANDARD IN 3D PRINTING

By Stratasys

Connex™ 3D Printing was a major advancement in additive manufacturing when it launched in 2007. This PolyJet™ technology was the first to offer multi-material 3D printing, from rigid plastic to rubber-like and opaque to transparent, giving engineers the ability to print smooth and strong composite materials thanks to Digital ABS™.

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

Connex3™, now the industry standard in multi-color, multi-material, plastics 3D printing, combines three base materials and offers rich, vibrant colors and an expansive material selection. Connex3 technology is offered in three build tray sizes: 260, 350 and 500.

Connex3 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 (Figure 1).

The product realism and enhanced functionality bring parts to life.

Connex3 3D printed parts perform well both visually and functionally. The product realism and enhanced functionality bring parts to life, satisfying the artist, designer, engineer and product manager. Manufacturing engineers are pleased with Connex3's rugged Digital ABS output for areas like injection molding and production parts. Connex3 is the technology for end-to-end prototyping needs in all product development stages.

CONNEX3 READY-TO-USE MODELS

Connex3 can build as many as 82 material characteristics into an individual part, assembly or multi-part job. That number is greatly expanded with the optional Stratasys Creative Colors™ Software, powered by Adobe 3D Color Print Engine. Users select from a wide range of material properties, colors and opacities to print ready-to-use models. It eliminates secondary operations, such as assembly and painting, all while delivering the same speed, precision and resolution as PolyJet technology.

MAXIMIZING CONNEX3 COLOR CAPABILITIES

Software add-on provides
quick workflow and expanded
graphic capabilities



Stratatsys Creative Colors Software, powered by Adobe 3D Color Print Engine, adds hundreds of color options to each palette and enables gradients such as those on this smart home controller prototype.

For 3D printing applications that demand detailed or naturalistic color designs in Rigid Opaque materials, an optional add-on to Objet Studio™ software empowers any Connex3 3D Printer to produce gradients, vignettes and texture mapping. Stratatsys Creative Colors Software, powered by Adobe 3D Color Print Engine, automates color assignment to free operators from manually picking colors shell-by-shell. The new Stratatsys Creative Colors adds a continuous spectrum of color between any two cells in the original Connex3 palettes.

How it works:

1. Design in any CAD program.
2. Open your 3D file in Adobe Photoshop™ CC and export it as a 3D PDF. The exported file is automatically repaired and a preview dialog presents any repaired faces.

3. Add the PDF file to Stratatsys Creative Colors and prepare a tray. Set preferred profile to achieve best color result, and view an accurate 3D color preview for as many Rigid Opaque palettes as you wish.
4. Print your model directly from Stratatsys Creative Colors.

Stratatsys Creative Colors makes Connex3 the only 3D printing technology to offer Adobe™ color management, and expands Connex3 applications into areas that would be impossible or infeasible with Objet Studio alone. Workflow, geometric fixes, realistic preview functionality and export previews for design review are designed to boost efficiency.

The add-on is recommended for realistic concept designs and presentation models that incorporate impressive graphic elements such as organic patterns or complex logos. Stratatsys Creative Colors does not support Digital Materials that incorporate any non-Vero base resin, so jobs containing those materials should be executed via Objet Studio.



Produce a wealth of gradients, vignettes and images from each color palette.

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Figure 2: Connex3 prints functional prototypes and ready-to-use models in an array of eye-popping colors.

Trek Bicycle Corporation, one of the first to use Connex3, found that the technology improved performance, increased operational efficiency and inspired color applications for end products. Patrick Zeigle, engineering tech, stated that rubber-like overmolded parts have better durability and stability with a Digital ABS understructure, and having three materials loaded in the 3D printer means less unproductive time for material swapping.

Seventy-five percent of Trek's Connex3 parts are Digital ABS with a Tango™ (rubber-like material) overmolding. But Zeigle noted that demand for more color parts is growing with hues from the Connex3 color palettes. "We color-coded four versions of a part made in one print job. It was a simple way to make part identification easy," Zeigle said. He also cited a bicycle saddle with color mapping to show a rider's pressure points (Figure 3).

Color

While multi-color 3D printing isn't new, it is uncommon. What sets Connex3 apart are qualities the users report that make Connex3 parts look just like their injection-molded counterparts.

- Color quality: Capable of printing color in plastics that are strong, smooth and can accommodate fine features.
- Deep, vibrant colors: The model material contains the color, which results in great vibrancy (Figure 5). Unlike other technologies, Connex3 does not rely on saturating a base material with "ink."



Figure 3: This color model shows finite-element analysis data in 3D.

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Figure 4: Connex3 allows for blending color and clear for translucent tinted lenses.

- Repeatability: Throughout a part, and from print job to print job, colors are consistent and predictable.
- Color throughout: The entire part contains color, not just the outer surfaces.
- Translucent colors: This 3D printer can mix one or two base colors with clear material, giving the user a range of translucency to print items such as tinted lenses and bottles (Figure 4).
- Color rubber-like: Connex3 can print rubber-like Digital Materials™ in a wide range of colors and Shore A values (Figure 6).

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.



Figure 5: These interlocking color rings were 3D printed in one job using the cyan-magenta-yellow palette.

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Figure 6: The Connex3 3D printed this colorful, flexible keyboard in one job by combining clear rubber-like and yellow and magenta colors.

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

With the third material, Connex3 can 3D print parts using Digital ABS (or another Digital Material) plus

one other, dissimilar material (Figure 7). Rubber overmolded parts with Digital ABS are possible, or the third material means Digital ABS can be combined with color accents or clear features.

Digital ABS 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 and also achieve a range of Shore A values into one component.

Several Digital Materials blend Digital ABS with rubber-like materials for a hardness range from Shore A 27 to Shore A 95. These materials are especially useful in production applications, like custom jigs and fixtures with non-scratch surfaces and durable rubber-like grips.

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

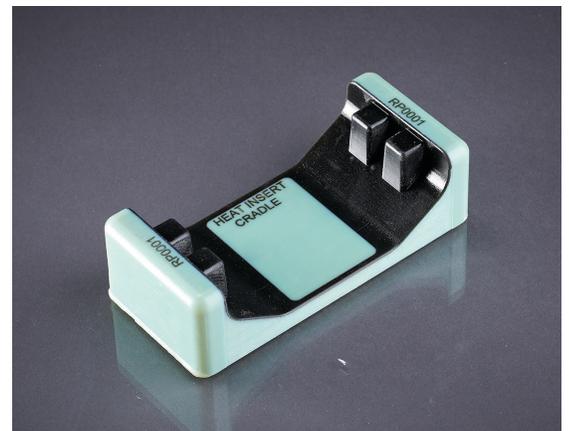


Figure 7: Connex3 can combine durable Digital ABS material with a dissimilar material, such as rubber or clear, in one part or job.

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yield Digital Materials, which are more than a simple blending of base materials.

The rigid palettes

See “Maximizing Connex3 Color Capabilities” (page 3) to learn about add-on software that enables gradients, graphic textures and a streamlined workflow for rigid opaque parts.

Color: As with 2D printing, users load a combination 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 (Figure 9), each with 45 or 46 hues.

The flexible palettes

Color: 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 (Figure 11).

Properties: Users select from combinations of rigid and rubber-like materials. This produces Digital Materials with wide range of properties.

A single part could have, for example, a sturdy Digital ABS structure with a soft-touch rubber overmolding. According to Zeigle, “Digital ABS is superior for overmolding.”

The workflow

See “Maximizing Connex3 Color Capabilities” (page 3) to learn about add-on software that enables gradients, graphic textures and a streamlined workflow for rigid opaque parts.

The lifeblood of 3D printing, the STL, contains no properties information. So the approach is to create a CAD model as a multi-bodied assembly

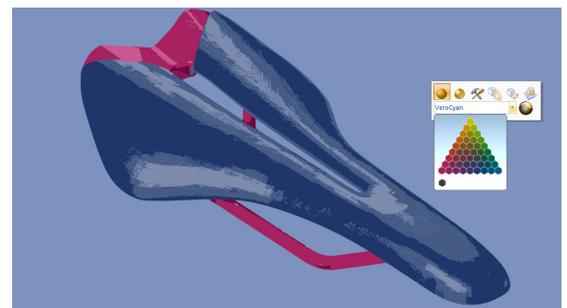


Figure 8: When the user clicks on a shell, Objet Studio software automatically displays composite material options based on the chosen three base resins.

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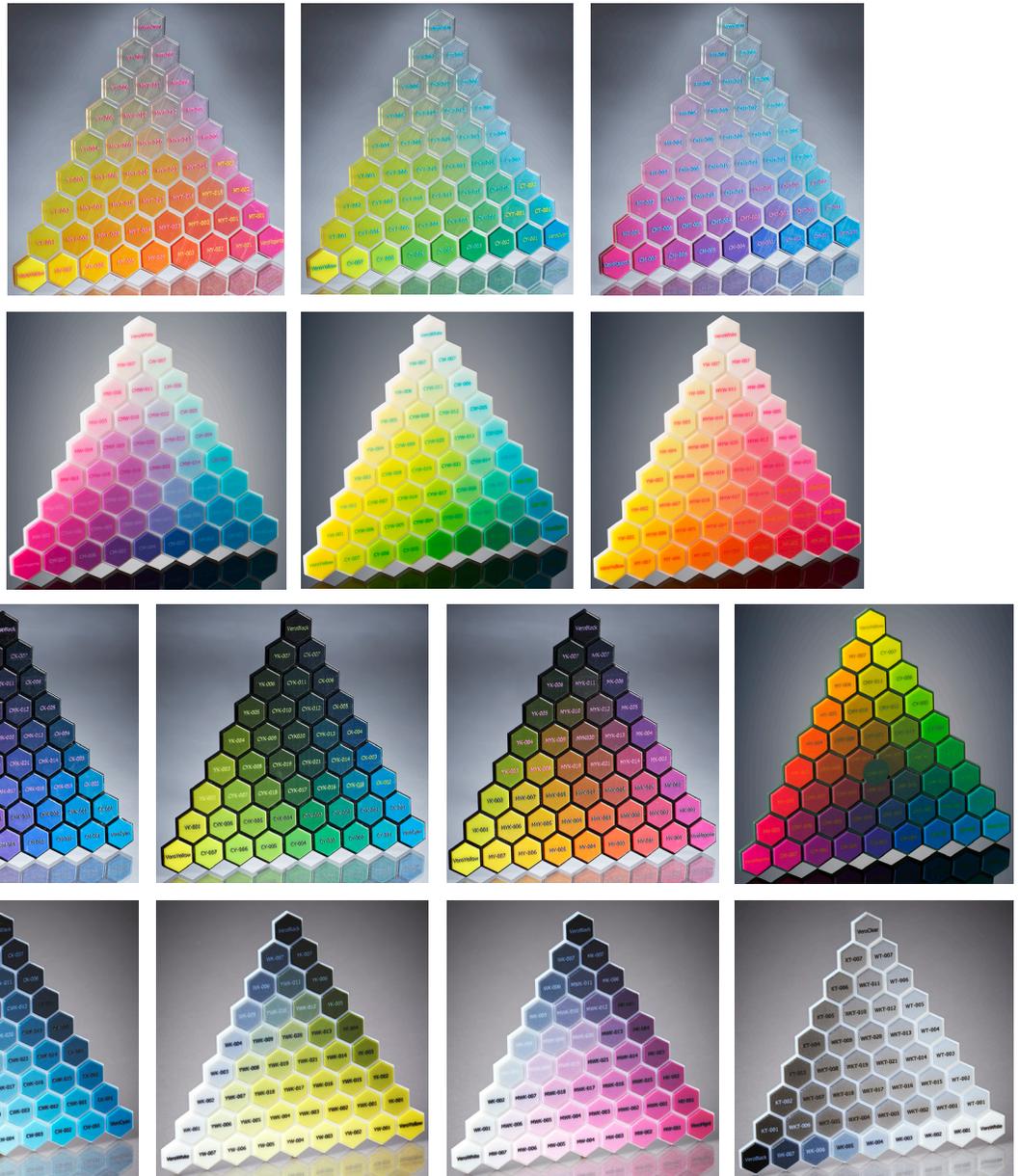


Figure 9: These 14 color palettes represent the color-blending capabilities of the Connex3. Each side and interior cell is a specially engineered Digital Material.

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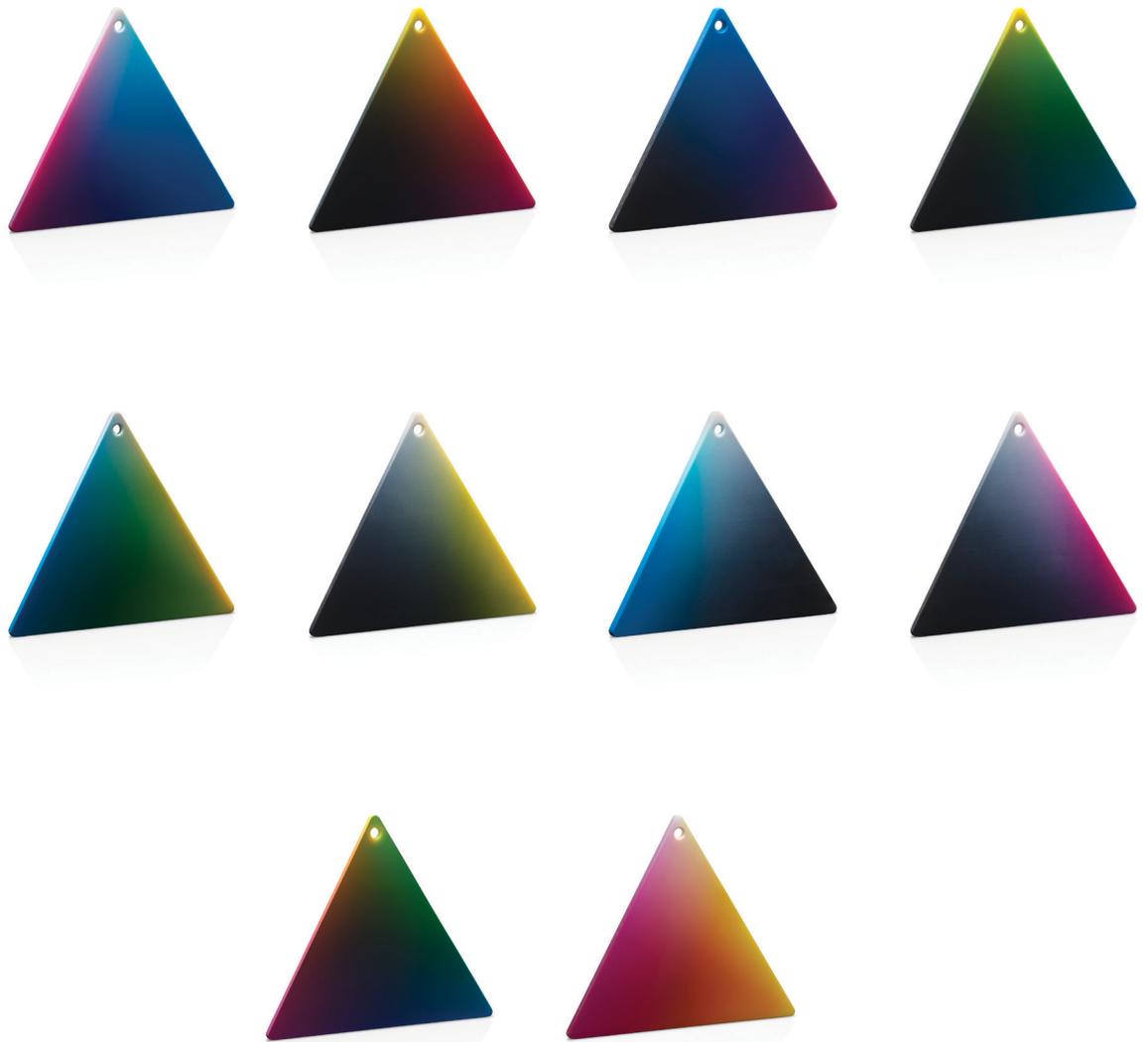


Figure 10: These 10 color palettes represent the increased color capabilities of the Connex3 with Stratasys Creative Colors Software. The gradients made possible by this software greatly increases the number of colors per palette.

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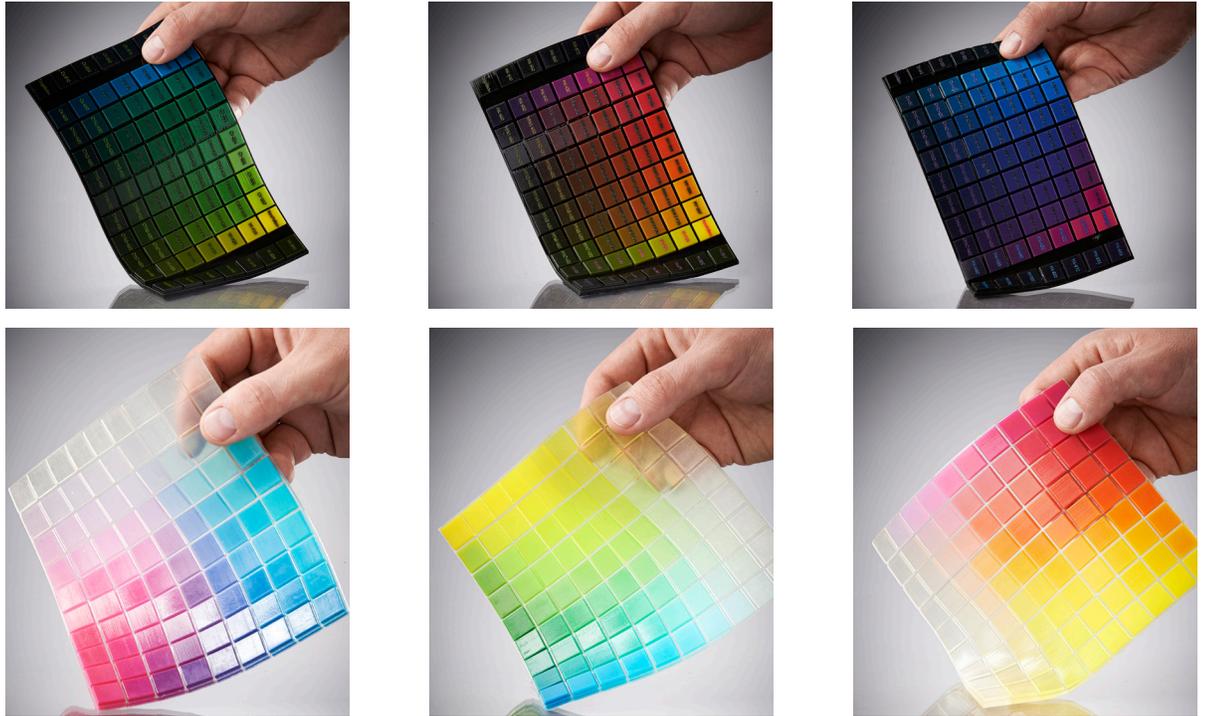


Figure 11: These six flexible color palettes provide a range of color options and Shore A values. Three 72-color palettes feature combinations of TangoPlus with VeroCyan, VeroMagenta and VeroYellow, while three 68-color palettes combine those same vivid colors with TangoBlackPlus.

and export as separate STLs. Zeigle recommends creating 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 be loaded in the Connex3. The software calculates

the resulting Digital Material options and provides a dropdown palette each time the user clicks on a shell (Figure 8).

Connex3 supports STLs and files exported from CAD in VRML format, as an alternative to STL. Note that while Objet Studio supports shell-based VRMLs, textures require the use of Stratasys Creative Colors Software. 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

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the operator to designate a color for each shell; and it provides Connex3's 10 Rigid Opaque color palettes directly in SolidWorks or Rhino.

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)

This is another way Connex3 provides flexibility to accomplish diverse tasks with one system.



Figure 12: 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 72 color options.

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

Early 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

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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.

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 and rubber-like parts by overlaying a thin shell of opaque or translucent color.



Figure 13: 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.

To add a layer of color over Digital ABS, 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.



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Conclusion

Connex3 provides vibrant multi-color and realistic multi-material 3D-printed parts without sacrificing speed, resolution or layer thickness. According to users, they get the color they need and the material properties they want with all the detail they expect from PolyJet technology. The Connex3's ability to shift between high-concept prototype designs in exacting detail and tough production-grade applications make it an invaluable addition to any company's production line.

With capabilities to serve a variety of applications in one system — while meeting a range of aesthetic and mechanical requirements — Connex3 is the industry standard in prototyping.



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