

OBJET[®] 500 CONNEX3[™]

HOW TO MAXIMIZE MULTI-MATERIAL AND COLOR POSSIBILITIES

By Stratasys[®]

Connex[™] 3D Printing was a major advancement in additive manufacturing. Launched in 2007, this PolyJet[™] technology was the first to offer multi-material 3D printing. A single part, or any collection of parts in a build, can have dozens of distinct material properties ranging from rigid plastic to rubber-like and opaque to transparent.

Connex 3D Printers achieve this by jetting two base model materials, in varying combinations, to build a part.



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 nine colors from blue to purple to magenta, plus flexible rubber-like components in black.

Although this was groundbreaking, Connex whetted the appetite. Shortly following its introduction, Connex technology also gave engineers the ability to print strong composite materials thanks to Digital ABS™. Digital ABS was the first PolyJet material that was smooth and strong enough to create molds for low-volume injection molded parts. Users saw many more applications on the horizon. They wanted more material combinations and more color options.

Objet500 Connex3 answers the call. In another first, it is a multi-color, multi-material, plastics 3D printer. It achieves this by jetting a third model material. Combining three base materials dramatically extends the possibilities — rich, vibrant colors and an expanded material selection.



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

Connex3 uses a new print block based on the established, proven Connex design. Stratasys also added three new base colors to the material mix — cyan, magenta and yellow — as well as newly engineered combinations of other base materials to offer hundreds of new Digital Material combinations. The striking blended color

palettes that result mean prototypes look more like off-the-shelf products (Figure 1) than their Connex predecessors.

With 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. Connex3 is a single technology for end-to-end prototyping needs in all product development stages.

CONNEX3

Connex3 can build as many as 46 material characteristics into an individual part, assembly or multi-part job. Users select from a wide range of material properties, colors and opacities.

Unmatched by any other 3D printing technology, Connex3 prints ready-to-use models. It eliminates secondary operations, such as assembly and painting, all while delivering the same speed, precision and resolution as its predecessor, Connex.

Trek Bicycle Corporation, one of the first to use an Objet500 Connex3, found that the technology improved product performance, increased operational efficiency and inspired color applications. For example, Patrick Zeigle, engineering tech, stated that rubber-like overmolded parts now have better durability and stability with a Digital ABS understructure, and that having three materials 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 now that multi-color 3D printing is available, demand is growing for parts with hues from the Connex3 color palettes. "We recently 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 2).

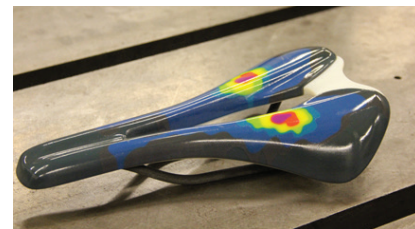


Figure 2: This color model shows finite-element analysis data in 3D.



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

Color

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

- Deep, vibrant colors: The model material contains the color, which results in great vibrancy (Figure 3). Unlike other technologies, Connex3 does not rely on saturating a base material with "ink."
- Repeatable colors: 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).



Figure 4: Objet500 Connex3 allows for blending color and clear for translucent tinted lenses.

- Color rubber-like: Connex3 is the first 3D printer to print color rubber-like. Print rubber-like Digital Materials™ in a wide range of colors and Shore A values (Figure 5).

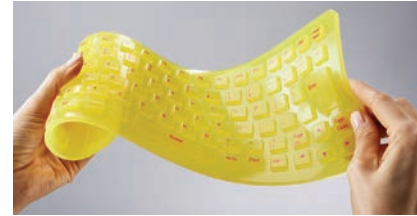


Figure 5: The Connex3 3D printed this colorful, flexible keyboard in one job by combining clear rubber-like and yellow and magenta colors.

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.

New 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 a three-base-material jetting technology offers this capability.

With the third material, Connex3 can 3D print parts using Digital ABS (or another Digital Material) plus one other, dissimilar material (Figure 6). So rubber overmolded parts with Digital ABS are now possible. The third material also means Digital ABS can be combined with color accents or clear features.



Figure 6: This prototype of an overmolded tool handle combines Digital ABS with rubber-like in one print job.

Digital ABS strength plus flexibility: Connex3 introduces the capability to not only use three materials in the same part, but also to create composite materials from three base resins. Before Connex3, users had to pick between the strength of Digital ABS and achieving a range of Shore A values. Now they can blend those two properties into one component. Stratasys engineers developed 12 new Digital Materials that blend Digital ABS with rubber-like materials for a hardness range from Shore A 27 to Shore A 95.

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.

The rigid palettes

Color: As with 2D printing, users load a combination from CMYK, which stand for cyan, magenta, yellow and black. When desired, users can also add 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™ and VeroClear™.

These combinations offer 14 color palettes (Figure 8), 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 have the option of three 72-color palettes, which feature a wide selection of Shore A values. With TangoBlackPlus, users have the option of three 68-color palettes, also with a range of Shore A values (Figure 9).

Properties: Users select from combinations of rigid, rubber-like and high-temperature 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 work flow

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 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 7).

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 from one of 20 palettes for each color print run, each providing 45 to 72 color options.

Since white and black appear in different color palettes, users will choose between light or dark hues. However, one palette — cyan, magenta and yellow — contains a bonus 46th color. It’s a dark gray that approximates black alongside vibrant, saturated primary and secondary colors.

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

Vibrancy

Connex3, like all Objet 3D Printers, 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.

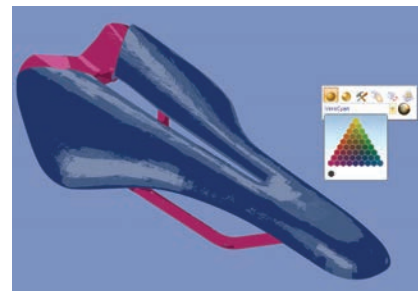


Figure 7: When the user clicks on a shell, Objet Studio software automatically displays composite material options based on the chosen three base resins.

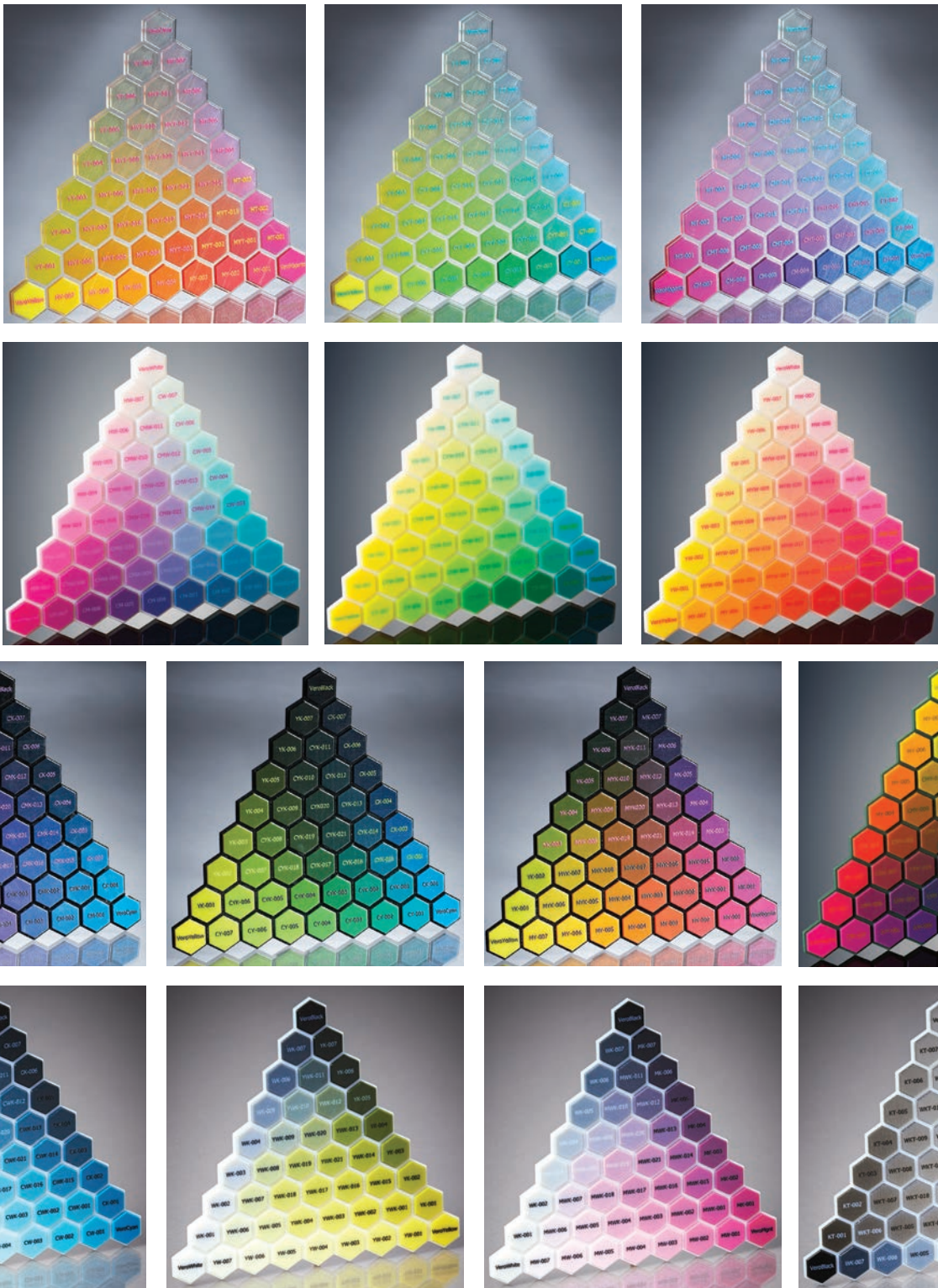


Figure 8: These 14 color palettes represent the color-blending capabilities of the Objet500 Connex3. Each side and interior cell is a specially engineered Digital Material.

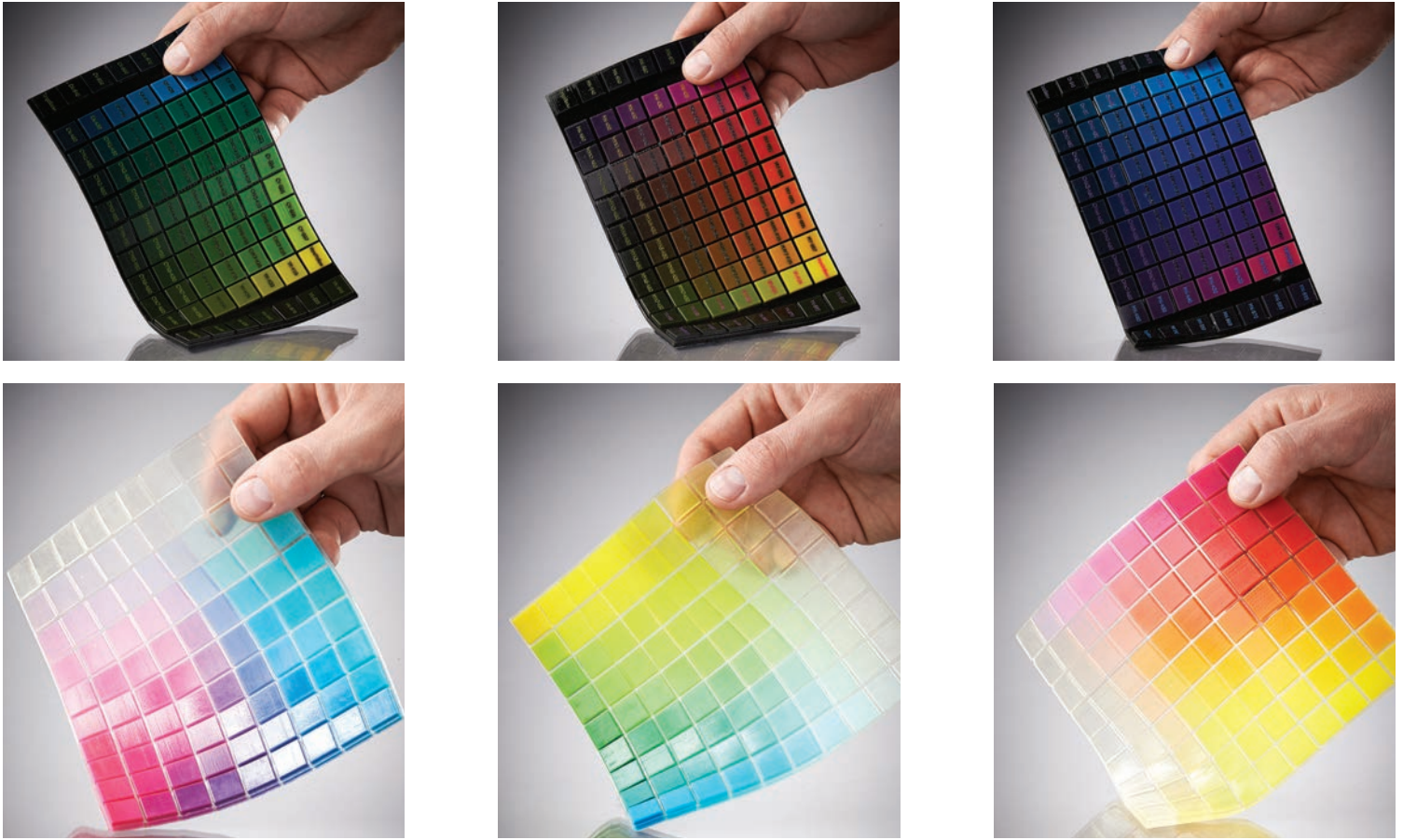


Figure 9: These six flexible color palettes provide a range of color options and Shore A values. Three 72-color palettes feature combinations of TangoPlus with VeroCyan, VeroMagenta and VeroYellow, while three 68-color palettes combine those same vivid colors with TangoBlackPlus.

TECHNIQUES

Early users of Objet500 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.

Work flow

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 what palette will be used in the next print run. This can minimize material changeovers by aggregating parts using the same palette.

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.

To add color to rubber-like features, a thin coating of a color material can be applied within the Objet Studio software. A separate shell for the outer surfaces isn't needed.

For 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.

CONCLUSION

Connex3 provides vibrant multi-color and realistic multi-material 3D-printed parts without sacrificing the speed, resolution or layer thickness of the original Connex. According to users, they get the color they need and the material properties they want with all the detail they expect from PolyJet technology.

It seems easy and obvious, but this is not a simple upgrade. It is a significant technology advancement.

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