Technical note

The HP Multi Jet Fusion voxel

Building 3D objects with controllable properties

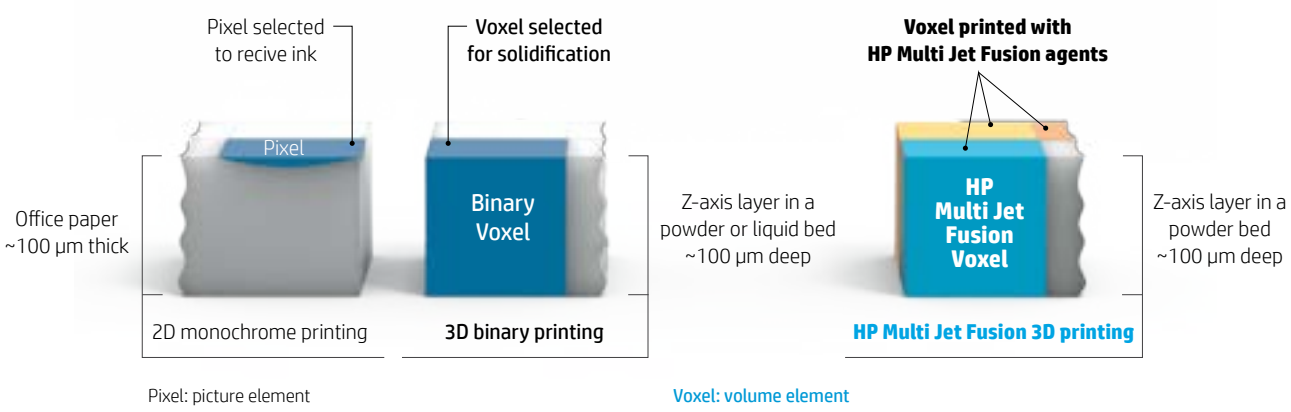
3D-printed objects are created from individually-addressable volume elements called *voxels*. A unique feature of HP Multi Jet Fusion is its capability to control the properties of each voxel to give unmatched capabilities to define the physical characteristics of an object point-by-point.

Introduction

Images in conventional prints and electronic displays are formed from *pixels*. Pixels are the dots that are printed (or emit light) at a specific number per inch ("dpi"), at a specific size, and with a specific color. The 3D analog of the pixel is the *voxel*. In 2D printing, pixels are arranged on a surface in a regular grid. In 3D printing, voxels are also printed in a regular 2D grid and a voxel has depth. Voxels form a thin layer that is a slice of a part's cross-section, and many such layers are stacked to form an object. While 100 microns is a typical value for 3D printing, the HP Jet Fusion 3D 4200 Printer can produce layer thicknesses between 70 – 120 microns (0.0025 – 0.005 in.). For the latest technical specifications, visit hp.com/go/3Dprint. Specifying the properties of each voxel defines a 3D-printed part point-by-point over its surfaces and within its volume.

In Figure 1, a 2D pixel is printed on a sheet of office paper about 100 microns thick; the two (2) voxels are printed in layers 100 microns thick. Figure 1 offers an analogy between printing pixels in a black and white image and printing voxels by conventional 3D technologies: a pixel is either printed or not, and a voxel is either fused or not.

Figure 1. Pixel, binary voxel, and HP Multi Jet Fusion voxels



HP Multi Jet Fusion advances 3D printing in the same way that adding color to inkjet printing expanded capabilities, applications, and markets. In 2D printing, multiple inks—cyan, magenta, yellow, and black—can be combined in pixels to print an image with a full range of colors. Using multiple *functional agents*, HP Multi Jet Fusion can print up to 1200 voxels per linear inch in each layer with a range of physical and functional properties including color. Functional agents are jetted by HP Thermal Inkjet Printheads to control the fusing and other properties of each voxel.

HP Multi Jet Fusion voxels are shown in color to signify the potential of HP Multi Jet Fusion to advance 3D printing to new levels. The breakthrough of printing *voxels whose properties can be individually-controlled* is made possible using HP's *functional agents* in the HP Multi Jet Fusion process. These agents are placed precisely in the working area of HP Jet Fusion 3D Printers by HP Thermal Inkjet Printheads.

Functional Agents

In the HP Multi Jet Fusion process, *Fusing and Detailing Agents* control the fusing of selected voxels and the edges between fused and unfused regions in each layer. Taking this process beyond the capabilities of conventional 3D printing technologies, *Transforming Agents* can create parts with controllably-variable—even quite different—mechanical and physical properties within and across a single part or among separate parts printed simultaneously in the build unit.

Transforming Agents control the interaction of the Fusing and Detailing Agents with each other as well as modify the properties of the fused material. Depositing Transforming Agents voxel-by-voxel across each layer allows HP Jet Fusion 3D Printers to produce parts that cannot be made by other methods.

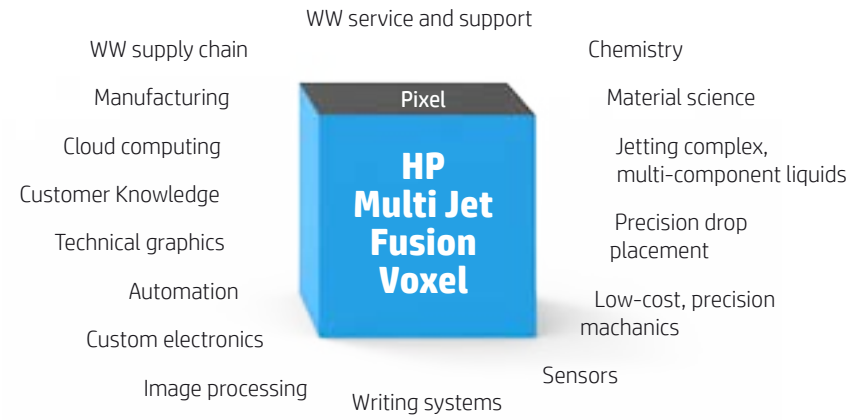
Properties that HP Transforming Agents could control within and across a part include

- Dimensional accuracy and detail
- Surface roughness, texture, and friction coefficient
- Tensile Strength, elasticity, hardness, and other material properties
- Electrical and thermal conductivity
- Opacity or translucency in plastics
- Color: embedded and at the surface

Using HP Transforming Agents, a part can have durable, hard surfaces with a low friction coefficient where contact and wear will occur, and different properties elsewhere to meet other functional requirements. Before HP Multi Jet Fusion, parts with these characteristics could only be made by assembling subcomponents providing each function or by multiple process steps including localized treatment—hardening, polishing, etc.—of selected surfaces by machining, chemicals, and lasers.

The ability of HP Transforming Agents to deposit conductive traces both embedded inside the part and on its surface will allow future generations of HP Jet Fusion 3D Printers to build intelligent parts that can measure and report their state during operation. For example, parts can have embedded strain gage arrays that accurately measure loads. This eliminates additional assembly operations, where strain gages must be precisely positioned and glued in place. Conductive traces can connect embedded and surface sensors with electronic circuits that process and report part status in real-time using visible indicators—such as light-emitting diodes—or by low-power wireless technologies.

Figure 2. Core competencies in 2D printing that HP brings to 3D printing



Taking HP Thermal Inkjet technology off the page into the three-dimensional world of additive manufacturing is a natural evolution of HP's three decades of expertise in digital printing and imaging. Figure 2 shows a pixel and HP Multi Jet Fusion voxel surrounded by the array of core competencies that HP brings to address the complexities and opportunities of 3D printing. HP Multi Jet Fusion is both new and built on a foundation proven by 100's of billions of pages printed by HP products based on HP Thermal Inkjet.

Just as HP's traditional printing solutions evolved from inkjet-based desktop printers in the 1980's to HP's high-speed commercial and industrial printing solutions of today, HP Multi Jet Fusion technology will evolve beyond the materials and capabilities of HP's rst-generation of HP Jet Fusion 3D Printers. HP's future in 3D printing will be realized through the possibilities HP Multi Jet Fusion affords to design and develop new materials digitally and at the voxel-scale.

Learn more at
hp.com/go/3Dprint

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