

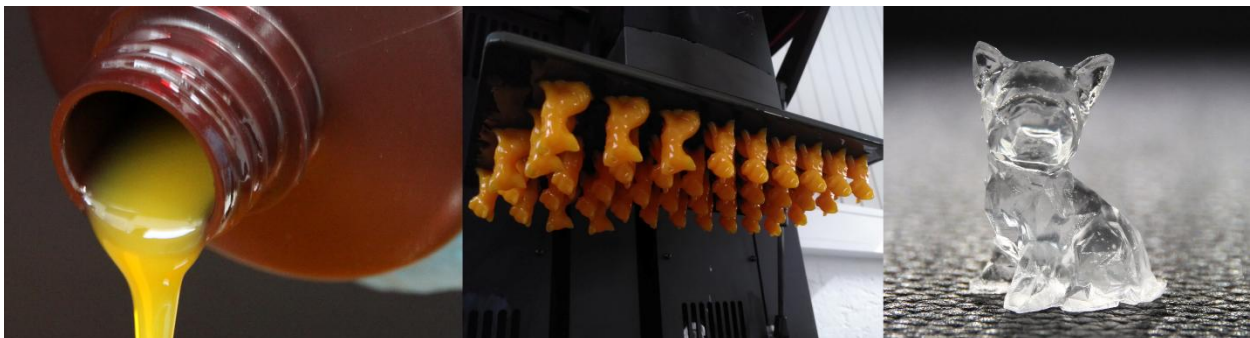
## Glass instrument making meets 3D printing of fused silica glass



A report by Frederik Kotz-Helmer

For centuries glass instrument manufacturing has stood for craftsmanship, precision, experience and artistry in handling one of the most fascinating materials of all: glass. With the development of 3D printing of fused silica glass based on the so-called Glassomer technology, completely new perspectives are now opening up for glass instrument manufacturing. The technology makes it possible to additively manufacture complex glass components and then further process them using traditional methods.

The Glassomer technology is based on a novel resin that contains a high proportion of glass particles. To produce the resin, a high-purity glass powder is introduced into a liquid binder. The resulting so-called Glassomer materials can then be processed in a standard 3D printer, where they are cured by irradiation with light. The resulting green body is then converted into a high-purity fused silica glass in an oven at 1300 °C by means of debinding and sintering. During this process, the components typically shrink by 24%. However, since the shrinkage is uniform in all spatial directions, it can be easily and precisely calculated and accounted for during the planning phase, resulting in dimensionally accurate components. The process from the liquid material to the finished glass component is shown schematically in **Figure 1**.



This technology is particularly interesting wherever complex or difficult-to-access geometries are required, for example, as in internal channels, microfluidic structures, or precise connections that are difficult to manufacture using classic methods (see **Figure 2**). 3D printing enables new shapes that were previously hardly feasible in classic glass instrument manufacturing. After printing, the glass components can be further processed as usually

done with glass. They can be polished in a flame, fused, or integrated into larger apparatuses. In practice, this means that only particularly complex and structured components are manufactured using 3D printing, while the rest of the apparatus is still constructed in the proven manner from tubes, standard parts, and manual labor. Glass apparatus manufacturing remains indispensable in this process. This creates a meaningful synergy between digital manufacturing and traditional craftsmanship. Especially with transparent materials like glass, surface quality plays a crucial role. The surface quality of 3D printed components usually always shows a certain structure from the layer-by-layer construction of the components. Here, too, the production of components using 3D printing benefits from the combination with classic methods such as flame polishing: effective post-processing allows the production of both glossy and matte components (see **Figure 3**).

The combination of both technologies opens up new possibilities in research, analytics, and laboratory development. 3D printing of fused silica glass offers a major advantage, especially for prototypes, small series, or special components: designs can be quickly implemented, tested, and then integrated into functional overall systems through glass instrument manufacturing. In this way, digital design and craftsmanship complement each other ideally. 3D printing of fused silica glass is therefore not a competitor to glass instrument manufacturing, but rather an expansion of its capabilities. Gertjan Bon's group at University of Amsterdam is among the pioneers in glass instrument manufacturing who have used 3D printing of Glassomer early on for the production of connecting elements, flow cells, and analytical accessories and holders (see **Figure 4**).

*"3D printing with Glassomer allows us to produce complex shapes from fused silica glass that would be very difficult or even impossible to realize with traditional glass processing. And the great thing is that the Glassomer parts are perfectly suited for fusing with fused silica tubes or fused silica glass," says Bon.*

Another example of the successful combination of 3D printing and traditional glass instrument manufacturing is the collaboration between Glassomer and Jürgen Klein (glass apparatus manufacturer at BASF). Together, a distillation column was manufactured using Glassomer 3D printing technology. The complex component (see **Figure 5**) was then successfully integrated into a larger glass apparatus by Klein and his team. By integrating such additively manufactured components, innovative production methods can be implemented that further increase both efficiency and quality in apparatus construction.

*"The collaboration between BASF Glass Technology and Glassomer demonstrates how innovation is redefining classic apparatus construction. 3D-printed fused silica glass parts create shapes that were previously impossible, and this is combined with traditional glass apparatus manufacturing. This expands the possibilities of glass apparatus construction and opens up completely new perspectives for researchers for complex applications." Jürgen Klein, BASF SE.*

Glassomer offers this technology in two forms: Firstly, the company sells the specially developed printing resins, which allow laboratories, research institutions, and universities to manufacture their own components. These institutions usually already have suitable 3D printers and only need the ovens for debinding and sintering. Secondly, Glassomer operates its own manufacturing facility where components can be produced directly according to customer specifications. Users thus have the choice of either printing themselves or purchasing finished quartz glass components. Components with dimensions of 160 mm \* 90 mm \* 150 mm and wall thicknesses of up to 8 mm are regularly manufactured in the production halls in Freiburg. Larger components and thicknesses are possible upon request.

From the very beginning, glass apparatus construction has accompanied and significantly shaped the development of 3D printing of fused silica glass. Without the knowledge and experience of skilled glass instrument manufacturers, the practical implementation of many concepts would hardly have been possible. Only through the interplay of digital design and traditional glass processing could functional apparatuses emerge from initial prototypes, which are already being used in everyday laboratory work today. As Klaus Paris, one of the first glass apparatus manufacturers to work with the Glassomer technology, describes it:

*"Initial skepticism turned into great enthusiasm when it became clear that the material quality surpasses our standard quartz glass and the possibilities for shaping are virtually endless."*

In addition to small series 3D printing, Glassomer also offers injection molding of quartz glass. An adapted manufacturing process makes it possible to produce solid granules that can be processed using injection molding machines. This enables the production of complex components with short cycle times and high throughput.

### Contact

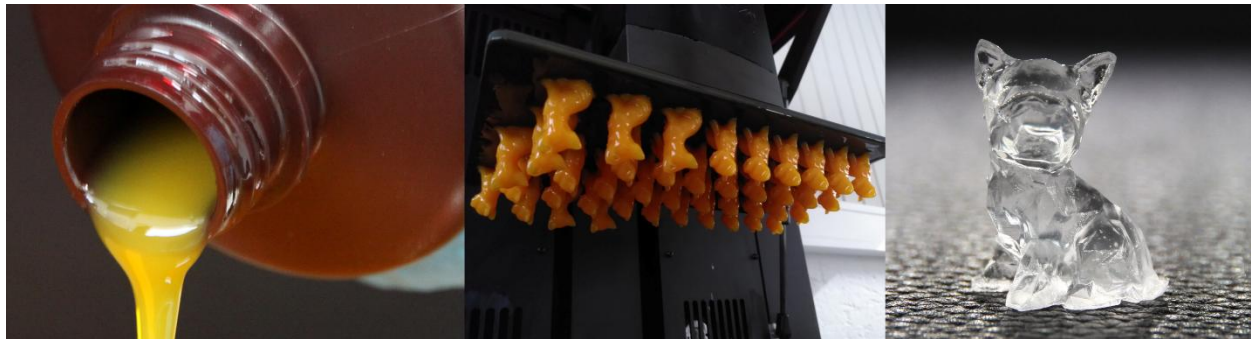
Glassomer GmbH

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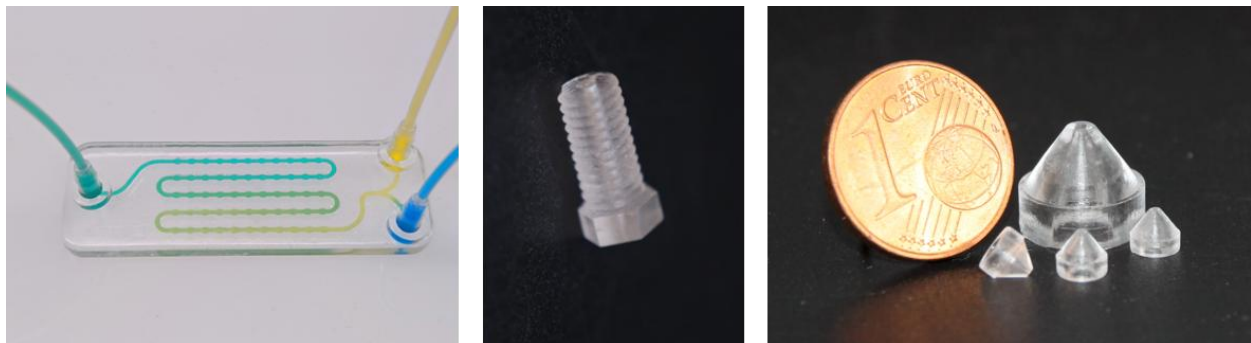
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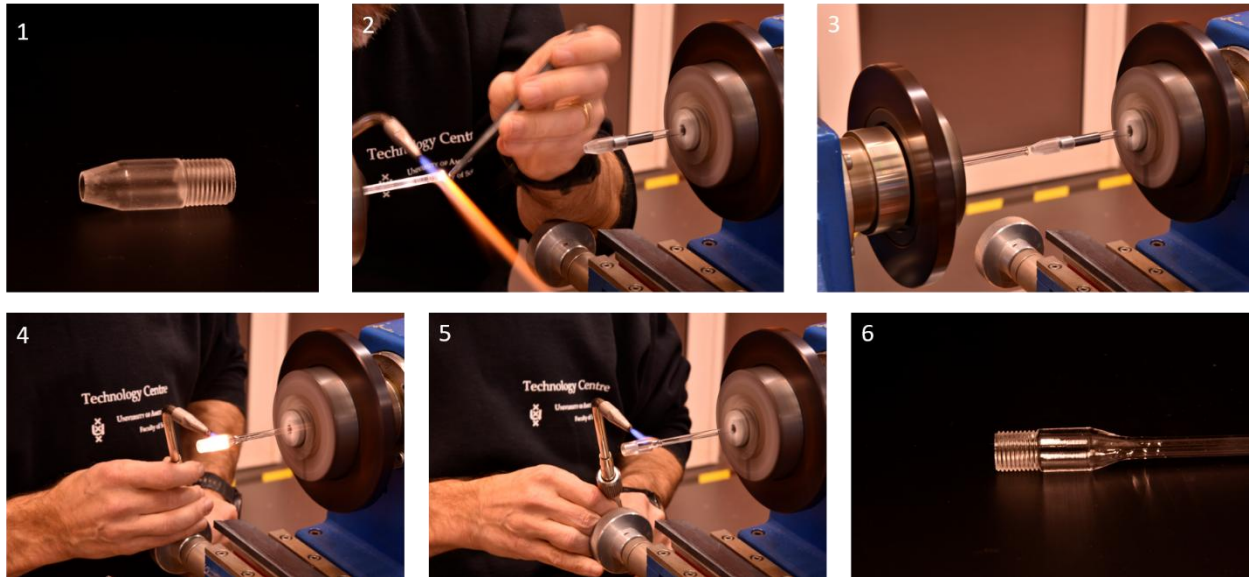
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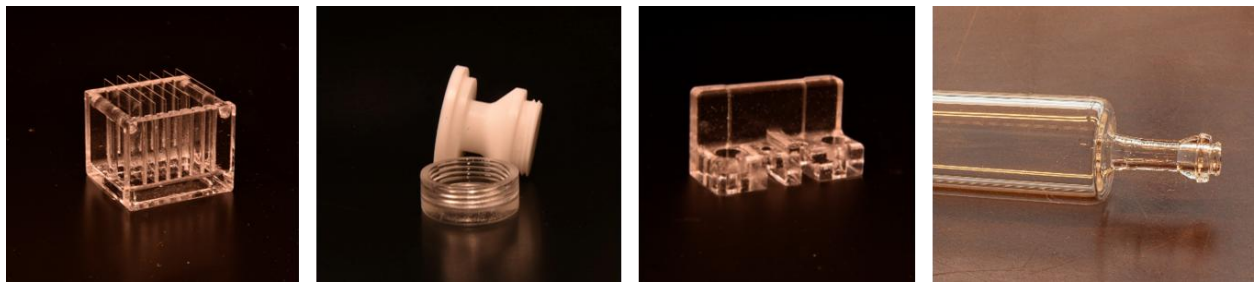
**Figure 1 Process overview – From printing resin to glass component:** Glassomer resin can be processed in standard 3D printers (SLA, DLP). UV curing produces a so-called “green body,” which is then converted into pure fused silica by debinding and sintering in a furnace.



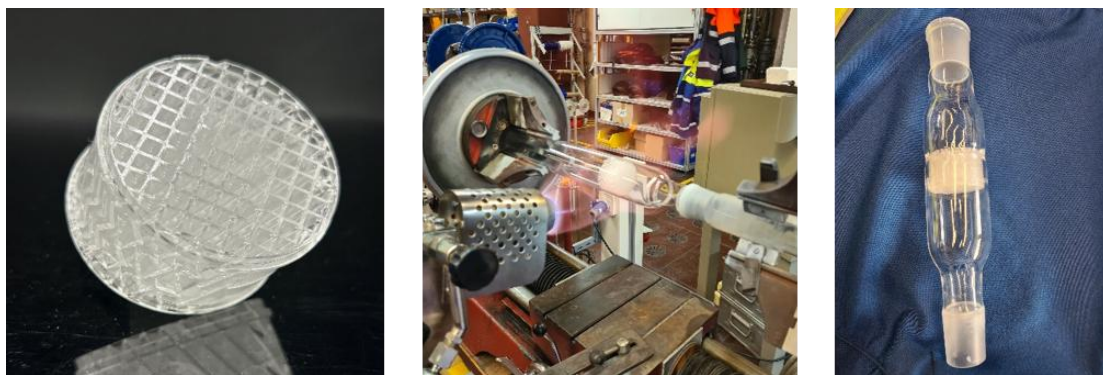
**Figure 2 Chemically and thermally stable precision components made of fused silica from the 3D printer:** Glassomer produces chemically resistant reactors with ultra-fine channel structures as well as high-temperature-stable nozzles.



**Figure 3:** Additive 3D printing of fused silica with seamless integration of components in scientific glassblowing, followed by final flame polishing (Gertjan Bon / University of Amsterdam).



**Figure 4** Scientific glassblower Gertjan Bon (University of Amsterdam) manufactures fused-silica components via 3D printing—such as holders, connectors, or complex parts—that are difficult or impossible to produce using traditional methods.



**Figure 5** 3D printing of a fused-silica distillation column and its integration in the flame (Jürgen Klein / BASF).