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GESIM

BioScaffolder

A Family of Versatile Bioprinters

- Pneumatic and mechanical extruders for high and low temperatures
- Automatic alignment of nozzles and substrate height measurement
- Micro-liquid handling from pl to ml
- Easy to use CAD import
- UV, FDM, core/shell, melt electrowriting, (gradient) mixing, plasma...

3D BIOPRINTING

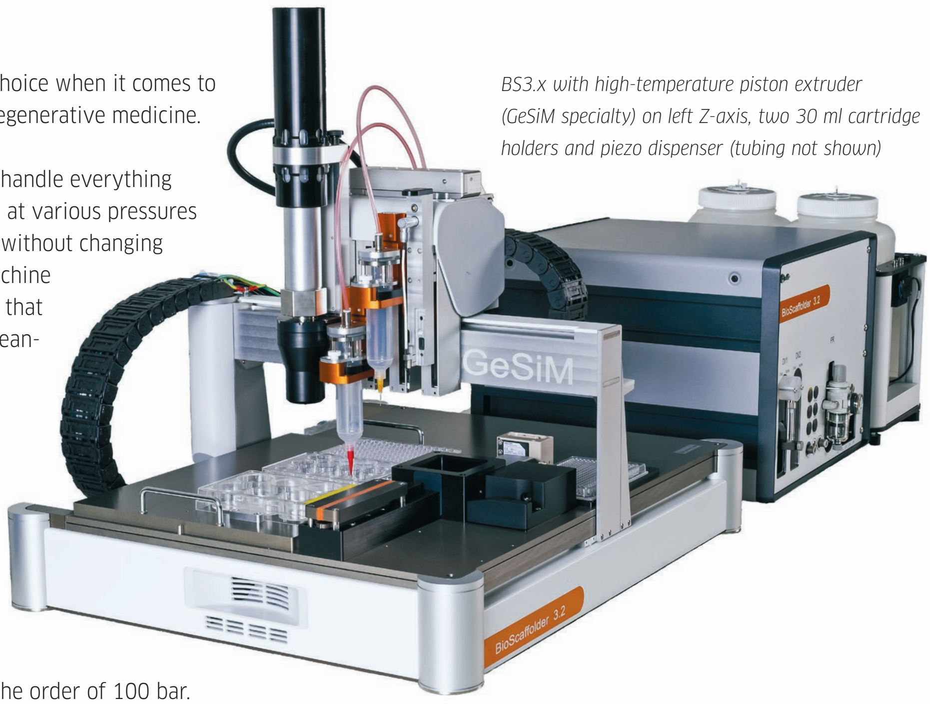
The BioScaffolder Series 3 and 5 Models

The small BioScaffolder BS3.3 and the BS3.3 Prime

The GeSiM BioScaffolders are your first choice when it comes to rapid prototyping for 3D cell culture or regenerative medicine.

The four drives on the **multi-Z** tool head handle everything from hydrogels to high-melting polymers at various pressures and temperatures between 5 and 250 °C without changing tools in the middle of your print. This machine gives you access to a wide range of tools that are easily installed and configured. Tip cleaner, automatic tip alignment and substrate height measurement are on board.

A unique option is **micro-liquid handling** that allows non-contact spotting of cell suspensions or drugs with high precision onto your scaffold. Another tool you won't find on many other systems is the **high-temperature piston extruder** that can print custom-made polymer granules at up to 250 °C at pressures of the order of 100 bar.



BS3.x with high-temperature piston extruder (GeSiM specialty) on left Z-axis, two 30 ml cartridge holders and piezo dispenser (tubing not shown)

All printers come with an easy to use software, of course with hassle-free **import of CAD data**, seamlessly integrating all tools in one automatic process or a sequence of processes.

We do our best to let you make the right choice for your budget. The small platform, **BS3.3**, is ideal for research labs and works with practically all dispensing tools. Price-conscious customers will like the **BS3.3 Prime** with three Z-axes and a set of popular printing tools, which is still ready for later upgrades. For sterile work, the BS3.3 and BS3.3 Prime fit in a biological safety cabinet (BSC); extra large BSCs can be obtained from GeSiM.

Higher throughput, enhanced functionality: BS5.3, BS5.3/E and BS5,3/CB

The BS5.3 platform with lightning-fast and accurate linear motors is designed for high throughput and 24/7 operation. Two machines exist:

- The small **BS5.3** (see front page)
- The large **BS5.3/E**

The BS5.3/E features twice the print size of the BS5.3 and can thus produce more and larger scaffolds and/or hold additional work deck tools such as heat beds, MTP coolers etc.

The more robust design of the BS5.3 family lets you use more and heavier (and special) tools, e.g. a high-temperature gradient mixer, as well as combinations of several of these tools at once.

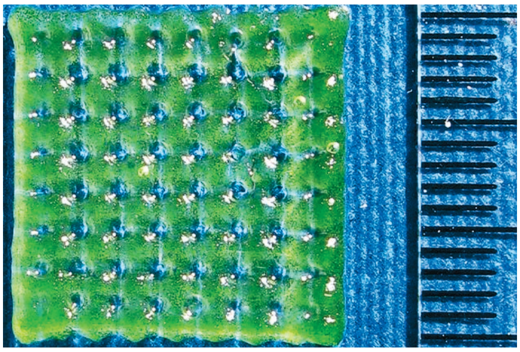
The software for all BioScaffolders (BS3.3/BS5.3) is consistent and very easy to use.

The BS5.3 is operated in a special containment, e.g. an **extra-large biosafety cabinet** (please inquire) with locked doors, or in a standalone unit with HEPA filters in which all accessory devices are tidily stored behind a door (picture)..

Blends of alginate and methyl cellulose for 3D printing

Alginate, a popular hydrogel, is often either too rigid or too soft for extrusion-based printing. To ameliorate this situation, the Gelinsky lab (TU Dresden, Centre for Translational Bone, Joint and Soft Tissue Research) have added methyl cellulose before printing. After cross-linking with Ca^{2+} and during the subsequent cultivation, the methyl cellulose is washed out and hence does not interfere with cell growth, as shown for various cell types including mesenchymal stem cells. *Ref.: Ahlfeld, T. et al., Biomater. Sci. 15, 2020, 2102–2110*

Using this method, they printed *Chlamydomonas reinhardtii* algae in an alginate scaffold, as an oxygen source for mammalian cell cultures. *Ref.: Lode, A., et al., Eng. Life Sci. 15, 2015, 177–183*



'Green scaffold' after twelve days of cultivation

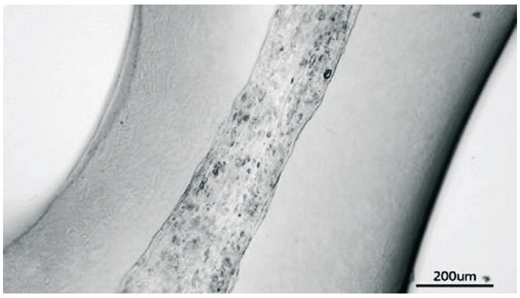
CT model of a scaphoid bone (left) and final product, after setting (right)

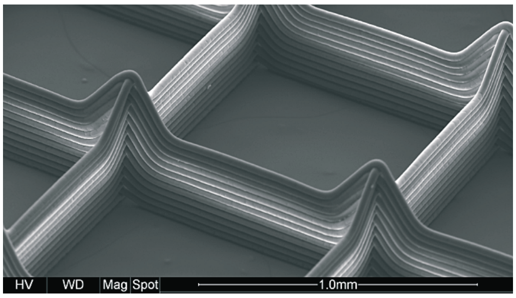
Reconstruction of human bone and cartilage

Bone replacement surgery usually involves sturdy titanium implants that are, however, not incorporated into live tissue. A joint project with the Gelinsky lab established 3D printing of patient-specific biodegradable implants. Here, an STL model of a human bone was constructed from a CT scan. Data were imported and printed using calcium phosphate cement from InnoTERE GmbH (Radebeul), finely dispersed in bioresorbable oil; it sets after immersion in water. By printing wide meshes into which cells can migrate, a structure can be created that becomes fully incorporated into living tissue (funded by AiF-ZIM programme, project no. KF2891602). Multi-material scaffold repairing both bone and cartilage defects were also generated. *Ref.: Kilian, D. et al., Bio-des. Manuf. 4, 2021*

Core/shell scaffolds

The combination of soft hydrogels with a stiffer (e.g. alginate or CPC) coating at the outside results in mechanically robust scaffolds. The pneumatic core/shell extruder, i.e. a core nozzle surrounded by a shell nozzle, allows coaxial printing of two different materials, with print parameters (pressure) individually set for both. It is great for embedding drugs or growth factors for slow release or to stabilize cells inside a hydrogel matrix. Nozzle diameters range from 100 to 5000 µm. Here is an example with cells grown in the core for 7 days. *Ref. (example): Akkineni, A.R. et al., Biofabrication 8, 2016, 045001*



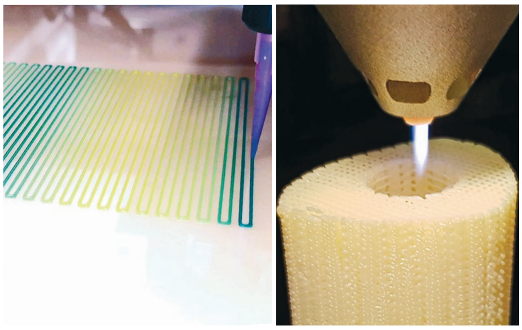


Melt electrowriting (MEW)

Deposition of biopolymer fibres at high voltage creates an attractive wide-pore support onto which cells adhere well. The picture shows an SEM image of accurately printed wide meshes of polycaprolactone (PCL) produced by MEW (courtesy of Dr. Cathal O'Connell, BioFab3D, St. Vincent's Hospital Melbourne). As another example, the Cabral lab at the Centre for Bioengineering & Nanomedicine, U. Otago, Dunedin, produces MEW scaffolds from PCL and milk proteins to obtain support structures for an in vitro skin model using human keratinocytes and human dermal fibroblast cells (not shown).

Affordable Implants by new hybrid 3D printing technology

The European 'FAST' project was initiated to explore the manufacturing of personalised, cost-efficient implants with certain properties (e.g. stiffness, porosity) by 3D printing. 'Smart fillers' with bioactive properties (e.g. antibiotics) were used to reduce the risk of post-surgery infections. For this, GeSiM developed gradient mixers operating at high and low temperatures (left picture). A cold argon plasma pen from Nadir s.r.l. (right picture; patent WO/2015/071746) has also been integrated; it can not only sterilize, but also etch and chemically modify surfaces with a range of functional groups (e.g. carboxyl, amino, epoxy) and coatings (silica, PMMA and others).

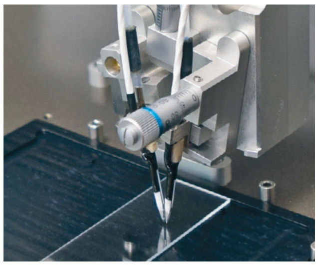


Pneumatically actuated printing of soft materials

Left: Peltier-cooled cartridge holder (min. temperature 4 °C). Top: heatable cartridge holder for up to 190 °C, with tip heater and polished metal tip.

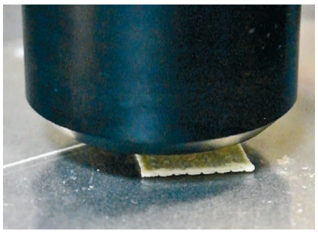
Micro-liquid dispensing of tiny drops

Non-contact piezo (ink-jet) printing onto water-sensitive paper. A useful alternative are solenoid valve dispensers for droplet volumes > 30 nl.

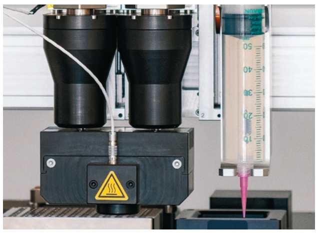


Twin tip for micro-droplet mixing; with automatic swivelling.

High- and low-temperature piston extruders



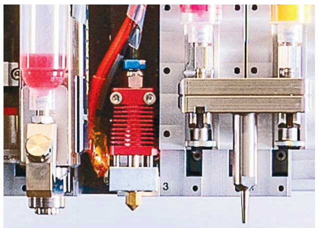
High-temp. (HT) piston extruder, here printing PEOT/PBT



Gradient mixer with two HT extruders (left) and syringe extruder (right)

Core/shell, FDM and other dispensers

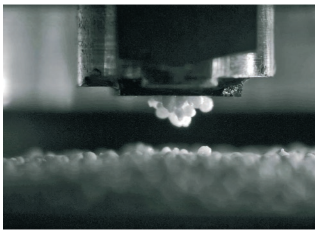
Enlarged view of a core/shell tip



Piezo valve dispenser, FDM head and gradient mixer (for RT).

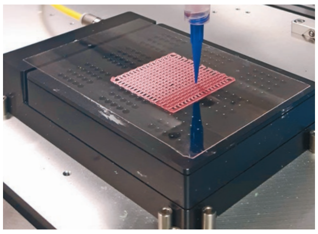
Adhesive and powder dispensers

Heatable piezo valve dispenser (VERMES) printing thermoplastic

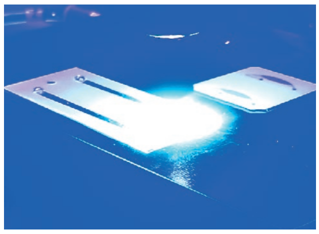


Low-volume powder dispenser tip transferring particles using suction

Work deck tools and UV illumination

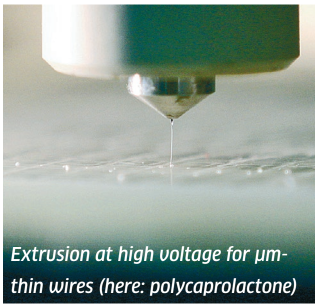


Substrate heater on a BS5.3 substrate tray, with holes for vacuum fixation



UV light sources are available for different wave lengths and intensities.

Melt electrowriting (MEW) and plasma



Extrusion at high voltage for µm-thin wires (here: polycaprolactone)

Plasma pen (Relyon) for sterilization and surface modification

More tools (GeSiM and third-party suppliers)

Many other tools (e.g. stirrers) on the print head and the work deck exist, some especially designed for liquid handling. One of these interesting tools is an automatic pipetting head that can handle both Luer-Lock needles and disposable pipetting tips. Please consult our catalogues.

Manufactured by GeSIM, distributed in the UK and Ireland by **analytik.**