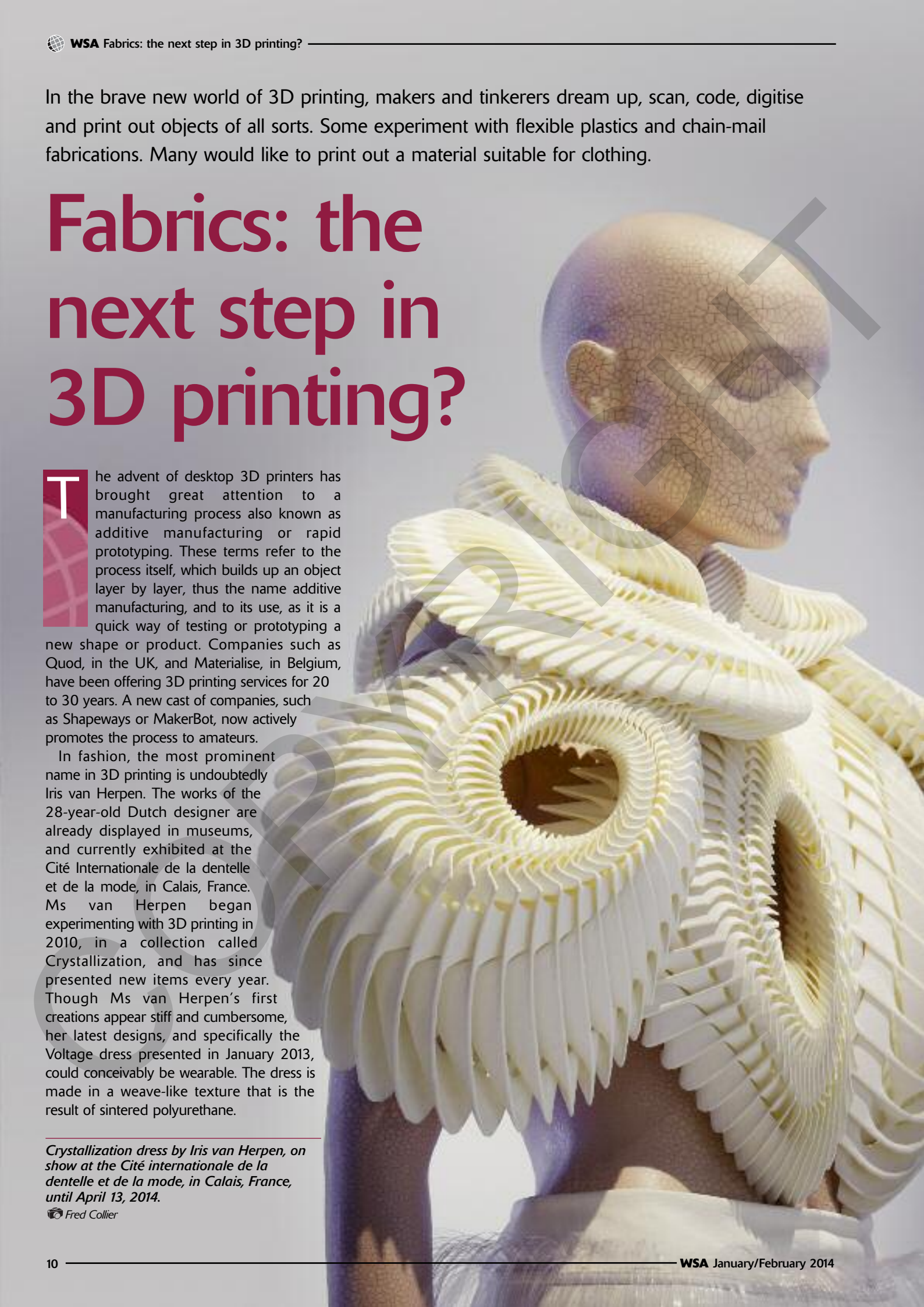
In the brave new world of 3D printing, makers and tinkerers dream up, scan, code, digitise and print out objects of all sorts. Some experiment with flexible plastics and chain-mail fabrications. Many would like to print out a material suitable for clothing.

Fabrics: the next step in 3D printing?

The advent of desktop 3D printers has brought great attention to a manufacturing process also known as additive manufacturing or rapid prototyping. These terms refer to the process itself, which builds up an object layer by layer, thus the name additive manufacturing, and to its use, as it is a quick way of testing or prototyping a new shape or product. Companies such as Quod, in the UK, and Materialise, in Belgium, have been offering 3D printing services for 20 to 30 years. A new cast of companies, such as Shapeways or MakerBot, now actively promotes the process to amateurs.

In fashion, the most prominent name in 3D printing is undoubtedly Iris van Herpen. The works of the 28-year-old Dutch designer are already displayed in museums, and currently exhibited at the Cité Internationale de la dentelle et de la mode, in Calais, France. Ms van Herpen began experimenting with 3D printing in 2010, in a collection called Crystallization, and has since presented new items every year. Though Ms van Herpen's first creations appear stiff and cumbersome, her latest designs, and specifically the Voltage dress presented in January 2013, could conceivably be wearable. The dress is made in a weave-like texture that is the result of sintered polyurethane.



Crystallization dress by Iris van Herpen, on show at the Cité internationale de la dentelle et de la mode, in Calais, France, until April 13, 2014.
Fred Collier

(Left) Voltage 3D printed dress made by Iris van Herpen and Julia Koerner with Materialise and presented in January 2013.

(Right) A scarf made by Janne Kyttänen, founder of Freedom of Creation, one of the first designers to explore 3D printed chainmail.

Michel Zoeter and Iris van Herpen / Janne Kyttänen

"Flexibility can be achieved not only by the material but also by the design," says Sven Hermans, project manager at Materialise who has worked with Iris van Herpen. Most materials, he agrees, still fall short of a fabric's suppleness: "To be truthful, we do not yet have the ability to make a material comparable to silk or cotton. The plastics we use do not have a nice touch."

"Iris van Herpen's work is as close as one gets to 3D-printed clothing made in a material comparable to fabric," says Paulina Perepelkin, close observer of 3D printing as it pertains to fashion. She dedicated her thesis to the subject and runs a blog called Additive Fashion. Ms Perepelkin traces the first textile-like 3D-printed objects to a bikini made in 2001 by Finnish designer Janne Kyttänen, founder of Freedom of Creation. This Amsterdam-based company has since been acquired by 3D printing service provider 3D Systems of Rock Hill, South Carolina.

Objects created with desktop 3D printers, many of which were displayed at the Paris and London 3D Print Shows last November, are made in basic plastics that do not denote quality. Common materials include nylon, polycarbonate (ABS) and PLA, the latter said to be biodegradable. Softer and more flexible items are made in thermoplastic polyurethane (TPU) or silicone. Few 3D printers are capable of combining different materials, with the exception of multimaterial devices made by Objet, an Israel-based company that merged with Stratasys in 2012. The two companies combined claim to have sold 60,000 printers.

Catherine Andreozzi, fashion designer and associate professor at the Rhode Island School of Design, is working on creating a 3D-printed lace-like material that will drape over the body using a resin plastic. "The number of materials available is limited today, and they are not very flexible, but it's just a matter of time before they come to market," she says, adding that experimentation can be costly. Her 3D-printed shoes cost $2,700 to make.

The range of raw materials available to print does expand regularly. A new series of 3D printers developed by Mcor Technologies, based in Ireland, transform basic sheets of paper into three-dimensional objects. In France, Le Fab Shop is introducing an algae-based plastic developed with Algopack, a company located in Brittany, and claims that this SeaWeed Filament (SWF) is the first bio-sourced 3D printing material.

Aiming for flexibility

During a keynote speech at the Paris 3D Print Show in November, MakerBot president, Jenny Lawton, announced the imminent launch of a more flexible plastic, without revealing its composition. NYC-based designer Francis Bitonti tested the material to make a dress, called Verlan, that was on display at the show. The looped "fabric" design appears to be somewhat flexible, though manufacturing lines remain

visible on the finished piece. This is not Francis Bitonti's first foray into additive manufacturing as he is the one who designed a 3D printed dress for Dita von Teese, manufactured by Shapeways on a Stratasys machine.

Stratasys' European marketing manager, Eric Bredin, says it is possible to "simulate" 120 different materials using the company's range of 14 base substances. The most pliable plastics, in the Tango family, are rubber-like elastomers and were introduced in 2008. The finesse of the layers can influence the touch of the object. The finest materials produced on Objet machines can go down to 16-micron layers, says Mr Bredin.

Some machines 3D sinter objects from nano-fine powders, the smallest of which measure 100 nanometers and are delivered in liquid form. These raw materials allow high resolutions, as seen in a chain-link cube made by a University of Nottingham research laboratory, the EPSRC Centre for Innovative Manufacturing in Additive Manufacturing. "Chain-mail is rather easy, but we aren't yet capable of achieving the smoothness of a silk fabric," says Maisam Askari, a member of the team.

A hybrid approach

Fashion designers could find 3D printing useful for developments in haute couture and specific items for catwalk presentations. "Some of the pieces currently shown on the catwalks cannot be considered wearable, nor are they made to be sold to consumers. This is essentially the situation one has with current 3D printed designs," says Stephane Madoeuf, one of the three founders of PrintaBit, a Swiss start-up that would like to be considered a 3D printing "curator" service for designers and artists. Tomorrow, he says "there's no reason why one couldn't combine 3D printing with traditional garment making techniques".

Compression wear specialist Zensah is tagging along the 3D printing bandwagon, literally, by offering 3-D printed swags, small tags through which shoelaces can run. The Florida-based company hired an engineer trained in additive manufacturing and launched its first product at Outdoor Retailer last August. The customised swags are made for runners looking to flag their favourite distances, from 26.2 to 140.6 miles, available in kilometres too. The tags are currently made in PLA, but the company is working on a more flexible material to create a swag that can be worn on the wrist. Zensah CEO and founder Ze'ev Feig sees 3D printing as a new service: "The internet has made B-to-B and B-to-C business much easier. The swags are a way for us to make a connection with our end consumers that was not possible 10 years ago." The just-in-time factor is one prospect he views as particularly interesting: "We could print out items right after the Sunday evening football game." This would allow fans to 'wear' the score, if the game goes in their team's favour. The company is also looking to apply 3D printing to compression wear. "I can't wait for the day when we will be able to print out a shirt," says Mr Feig.

3D printed briefs

Falling somewhere between additive manufacturing and non-woven production, the two processes are somewhat related. Tamicare in England is close to launching what could be considered the first 3D-printed garments, disposable panties. Tamar Giloh, Tamicare founder and inventor of the Cosyflex 3D printing process, started working on the project in 2006. The first products could be available in mid-2014. Tamicare would like to launch the concept on the premium market and with a big brand: "We have a lot of experience in innovation, and need a partner with a strong background in marketing," she says.

Tamicare's garment manufacturing method is designed for mass production: a panty is sprayed onto a mould in just 3 seconds, and speeds along a conveyor belt. The material sprayed is a combination of "purified" latex (natural rubber) with cotton or viscose fibres. Different polymers can be combined and assorted ingredients or elements added during the process (cosmetic, medical or even electronic). "The options are virtually unlimited", says Ms Giloh.

Like most 3D printing techniques, the Tamicare process produces no waste. "We reclaim the material that is over-sprayed during manufacturing." The process does not require high temperatures, and can therefore be considered low energy. Many companies have expressed interest in the process, says Ms Giloh,

Compression specialist Zensah 3D prints runner swags in the distance of their choice.

Zensah

Cosyflex is produced by an additive manufacturing process developed by Tamicare.

Tamicare

3D manufacturing, briefly

Fused Filament Fabrication or Fused Deposition Modelling (FFF or FDM): These are the most common 3D printing method, in which a plastic filament or metal wire is fed through an extrusion nozzle that heats, melts and deposits the material in layers. Available materials include various types of thermoplastics (and chocolate!). Some devices allow several materials to be printed at the same time. A wide range of colours is also available, as the filament comes in varied tones. The process requires little or no finishing, and produces no waste material. Its drawbacks include the level of resolution of the printer, which defines the level of detail that can be achieved, and the deposited layers tend to remain visible. There are no "scaffolding" options, which means that complex objects are harder to print. FDM is the name coined and trademarked by Stratasys, while other companies use the term FFF. Filament machines are cheaper, and sometimes called desktop manufacturing.

Selective Laser Sintering (SLS): A powder-based manufacturing process in which the powder is sintered (hardened) into a three-dimensional shape. A wide range of materials can be used, including assorted polymers (elastomers for flexible items), plasters, ceramics and metals. SLS is used to create shapes not possible with other manufacturing methods. Once finished, the powder that hasn't been sintered is removed and can theoretically be reused.

Stereolithography (SLA): The sintering of a liquid, often an epoxy-based material. Commonly used for jewellery, it allows for more detail and precision. Here again, excess material needs to be washed away after manufacturing. A support structure or scaffold is printed at the same time and then removed afterwards.

Source: www.additivefashion.com

who sees compression wear as possible sports application: "Our material stretches in all directions and we can vary the level of compression. We could also make a fabric in which the levels of waterproofness and breathability vary in different places."

New manufacturing rules

With the exception of the semi-industrial Tamicare process, 3D printing tends to be promoted for its ability to make a single, customised item, one piece at a time. This is why the process is often dubbed rapid prototyping. Sven Hermans, at Materialise is quick to point out that 3D printing may be "rapid prototyping, but it is slow manufacturing". The Verlan dress designed by Francis Bitonti required 400 hours of printing, comparable to the time needed to make some haute couture dresses by more traditional methods.

While many would like to see more materials made available, Paulina Perepelkin doesn't consider the machines or the limited array of plastics as obstacles to future 3D-printed developments in fashion. She believes rather that what is lacking are the skills and the knowledge base. Talent and understanding how best to use the machines may be where progress is due in a field that is being billed as the next industrial revolution, without mentioning whether it will be fast or slow.