Fraunhofer ICT

# Programmable materials

## A paradigm shift in materials engineering

**Programmable materials have the potential to dramatically change the future design, manufacture and use of materials by implementing system functionalities at material level. For this purpose, materials are constructed from small repeating units – so-called unit cells. By designing the unit cells, a defined material behavior or algorithms can be built into the material, enabling a defined, complex response to external influences.**

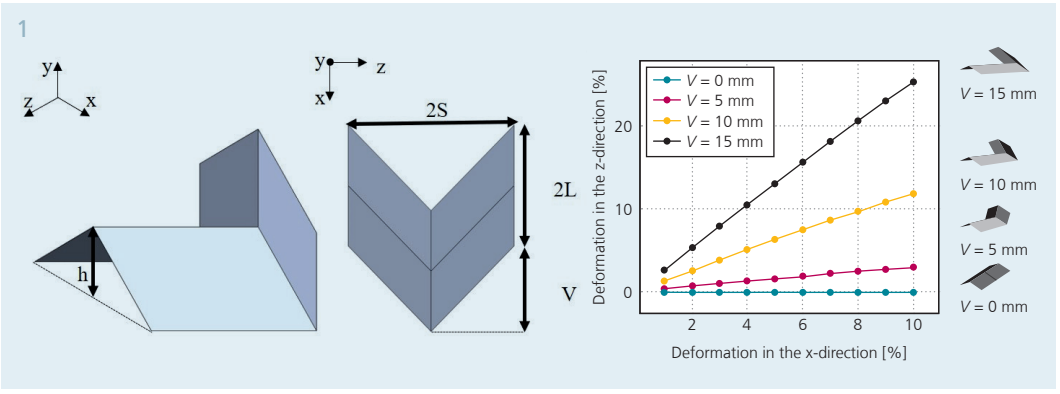
One example is local shape morphing by using unit cells with different auxetic properties (see figure 1). By programming the material, it is possible, for example, to achieve a defined, asymmetrical deformation of a component as a function of an uniaxial load (see figure 2).

### Application example

One potential application for programmable materials is a shoe sole (see figure 3). By varying the unit cell geometry and structure across the volume of the sole, the compressive stiffness can be adjusted locally.

In the areas subject to higher loads (e.g. forefoot or heel), the sole can be set to a defined stiffness level, while in the middle area it can be made less compressively stiff and at the same time as flexible as possible. Furthermore, the sole could be designed to adjust automatically to external influences such as the weight of the wearer or the surface during a sporting activity, which reduces the strain on the joints and increases wearer comfort.

1




2

*Figure 1: Miura-Ori structure with geometry parameter offset V (left) and correlation between strain in the z-direction and x-direction as a function of the offset (right).*

*Figure 2: Test component made of unit cells with defined variation of the offset to generate an asymmetrical change in width under uniaxial compressive loading.*

## Development of programmable materials for technical products

The Fraunhofer Cluster of Excellence "Programmable Materials (CPM)" develops programmable materials for applications in an industrial environment. Several Fraunhofer institutes combine their expertise and operate together as a virtual institute. For mechanically programmable materials in particular, a development environment (ProgMatCode) has been created, created, that makes key development steps accessible through simulations. This includes all aspects from the design and combination of unit cells through to their parameterization with regard to an application and their production.

In addition to mechanically programmable materials, different Fraunhofer institutes are researching and developing material solutions for programmable heat transport and friction.

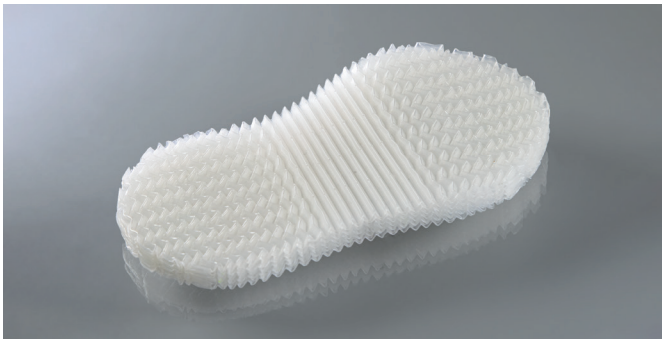


*Figure 3: Application example – shoe sole.*

## Production technology

The manufacturability of the material must be taken into account from earliest design phase, especially in the case of mechanically programmable materials which consist of a large number of unit cells. In addition to conventional manufacturing processes, new production methods must also be used, for example by combining different manufacturing techniques to ensure that the materials can be produced in series.

Fraunhofer ICT is working on the development of manufacturing methods for polymer-based programmable materials, while Fraunhofer IWU is focusing on methods for manufacturing metal-based programmable materials.

## Our offer

Do you see potential for improvement in your product? Or would you simply like to find out more about the potential applications of programmable materials? Get in touch with us! We will be happy to discuss how you can integrate functionalities into your product using programmable materials.

## Further information:

**www.cpm.fraunhofer.de**

## Contact

Dr.-Ing. Christof Hübner
Material development and compounding technologies
Phone +49 721 4640-458
christof.huebner@ict.fraunhofer.de

M.Sc. Angela Schwarz
Material development and compounding technologies
Phone +49 721 4640-825
angela.schwarz@ict.fraunhofer.de

Fraunhofer ICT
Joseph-von-Fraunhofer Straße 7
76327 Pfinztal (Berghausen)
Germany
www.ict.fraunhofer.de