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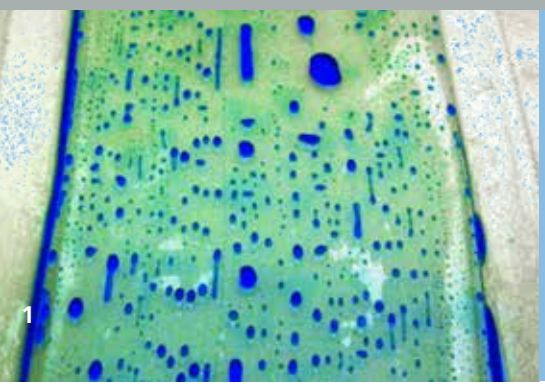

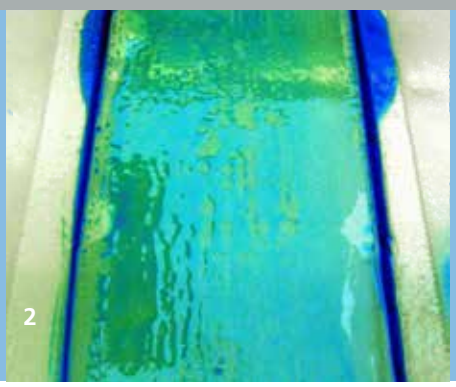

1 *Untreated silicone with colored water (droplet formation).*
2 *VUV modified silicone with colored water (liquid film formation).*
3 *Sloping surface: Slipping of the VUV treated ring (left); sticking of the untreated ring (right).*

RADIATION-INDUCED MODIFICATION OF SILICONE ELASTOMERS

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Silicones – highly valued materials

Silicones are ideal materials for a host of modern applications. This is demonstrated by their use in many sectors of industry. Silicones possess a number of beneficial properties, in particular their high flexibility, elasticity, and therm-al stability. They are, for example, favored in the medical sector due to their biocompatibility and chemical inertness.

These much-valued bulk properties are, however, not matched by their surface properties. In particular, the inert surfaces of silicones have poor bonding properties. The high surface tack of silicones also leads to:

- High friction values
- Poor cleanability
- Attraction of dust
- Unpleasant haptic properties

Modification with VUV radiation

The scientists in the Plasma Technology and Surfaces PLATO group at Fraunhofer IFAM have developed a way to overcome these disadvantages without losing the beneficial properties of silicone elastomers.

Using commercially available and easy to use VUV lamps (vacuum ultraviolet spectral range; emission of light with wavelengths less than 200 nm), the near-surface region of silicones can be modified to create a thin organosilicon layer.

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5

These modified surfaces are smoother and harder and consequently have new characteristics:

- Increased surface energy
- Reduced friction
- Dirt repulsion
- Pleasant haptic properties

The degree of modification can be controlled by judicious selection of the process parameters.

Pretreatment prior to bonding

According to the state-of-the-art, silicone elastomers are bonded with silicone and cyanoacrylate adhesives.

The VUV modification of silicone surfaces means that a wider range of adhesives can be used to join silicone components. For example, in the future epoxy resins, polyurethane adhesives, and acrylates will be able to be used, bringing the following benefits:

- A more versatile bonding process
- On-site activation
- New design opportunities
- Good storage stability
- Elimination of primer coatings

Friction minimization

The organosilicon layer makes the silicone surface hard and smooth. The depth of penetration of the selected VUV radiation leads to a radiation-induced modified layer of several micrometers. This comparable soft gradient results in good stability between the modified hard surface and the softer bulk material.

The lower static friction of the treated silicone components allows, for example, simplified assembly of hoses, rin¬gs, and connectors. The abrasion res¬istance of the silicone components is also improved.

Modification for medical and food applications

The use of VUV modification means that bonding processes for silicones can be carried out without employing adhesion promoters, many of which are harmful to health. In contrast to gas phase fluorination of silicones that involves incorporating foreign atoms (fluorine) into the surface, VUV modification does not lead to the presence of foreign atoms in the silicone. The pure quality of silicone materials is advantageous for medical and food applications.

Hygiene and cleanliness are vital in both these areas. This is aided by the reduced dust attraction and easier cleaning.
Prostheses have greater acceptance by the human body when they have pleasant haptic properties and are easy to clean. The lower static friction and dynamic friction of modified silicones are also beneficial, meaning that clothing is easier to put on over prostheses. These properties can be individually tailored by the VUV modification process.

Range of services offered by Fraunhofer IFAM

The Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM is your expert R&D partner. The range of services we offer includes:

- Sample provision
- Customized process development
- Pre-production runs
- Adaptation of existing processes
- Analysis of processes
- Quality assurance concepts
- Testing of layers/coatings

Fraunhofer IFAM can also provide assistance with the conception and design of plants for silicone modification to meet your specific needs.

4 + 5 *Silicone prosthesis half modified with VUV radiation: Significantly reduced dust attraction on the VUV modified section (left/top) compared to on the unmodified section (right/bottom).*