Motivation
Additive manufacturing allows for custom-made design of implants and medical devices. Here, the Ti-6Al-4V alloy, which is known to show good biocompatibility, is exploited as printing implants and medical devices. Here, the Ti-6Al-4V alloy, which is known to show good biocompatibility, is exploited as printing implants and medical devices. Here, the Ti-6Al-4V alloy, which is known to show good biocompatibility, is exploited as printing implants and medical devices.

Surface nanopatterning by block copolymer lithography
Block copolymer (BCP) lithography allows for the creation of ordered nanostructures. The microphase separation of PS-b-PMMA with a block length ratio of 70:30 for instance allows for the self-organised formation of hexagonally arranged PMMA cylinders in a PS matrix. The nanopatterns have well-defined dimensions in the sub-20 nm regime.

This technique can be applied on different materials surfaces. The nanopattern orientation with respect to the substrate is, however, determined by the interfacial energies between the polymeric nanostructured thin film and the substrate. While non-preferential wetting of the substrate with one of the BCP polymer species results in perpendicular cylinder formation (shown above), parallel orientation of the cylinders with respect to the surface is induced in case of preferential wetting with one polymer species (see right side).

Nanostructures on different titanium surfaces
Nanostructures in the sub 20-nm regime are created by block copolymer lithography. SEM images of nanostructured PS films on the different surfaces reveal that the pattern orientation with respect to the substrate drastically changes for the investigated surfaces. When created on pure Ti (left image) nanocylinders are perpendiculary oriented with respect to the surface (nanocylinders). On thermally treated Ti alloy (right image) nanopatterns are oriented parallel to the surface. This results in a fingerprint like surface pattern. A mixed state is found on the untreated alloy surface. This change of orientation results from the different surface polarities - predominantly dispersive surfaces (such as TiO$_2$ on pure Ti) induce perpendicular pattern orientation, while with Ti-6Al-4V alloy parallel orientation of the cylinders with respect to the substrate is induced.

Mechanical stability of 3D architectures
Experimental results and numerical simulations allow for determination of design rules for optimum device performance.

Heat treatment (2 h, 1050 °C) induces:
- transformation of α-martensite into (α+β)-phase

Resulting in a change regarding:
- mechanical properties
- physical (surface) properties
- chemical surface characteristics

AFM measurements reveal that surface roughnesses on the alloy surface are small, however, larger compared to the pure Ti surface. Contact angle measurements allow for the determination of the surface free energies (SFE). The alloy surfaces show a significantly higher polar fraction of the SFE than the predominantly dispersive pure Ti. The polarity of the alloys becomes even higher during annealing.

Structure & surface energy of Ti surfaces after thermal treatment
We investigate the surface characteristics of different TiO$_2$ surfaces, created by electron evaporation of Ti and oxidation at atmosphere, and on thermally treated 3D printed Ti-6Al-4V alloy surfaces.

<table>
<thead>
<tr>
<th></th>
<th>Ti (evap)</th>
<th>Ti-6Al-4V</th>
<th>Ti-6Al-4V + annealing</th>
</tr>
</thead>
<tbody>
<tr>
<td>roughness</td>
<td>0.5 nm</td>
<td>3-4 nm</td>
<td>4-7 nm</td>
</tr>
<tr>
<td>SFE</td>
<td>39 mN/m</td>
<td>43 mN/m</td>
<td>48 mN/m</td>
</tr>
<tr>
<td>(7% polar)</td>
<td>(26% polar)</td>
<td>(32% polar)</td>
<td></td>
</tr>
</tbody>
</table>

Compressive/tension-dominated applications:
- fcc-structure

Bending-dominated applications:
- fccz-structure

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