Osteoblastic cells on highly rough and porous implant surfaces

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Introduction

- A major task in biomaterial research is the functionalization of an implant surface to improve biocompatibility according to a specific application.
- Topographical surface modifications are a frequently employed, leading to a correlation between the bio-system and the surface structure.
- For flat and slightly rough substrates, atomic force microscopy (AFM) is an ideal examination method.
- For highly rough and porous surfaces, AFM is less applicable.

→ Supplementary examination methods are required for highly rough and porous structures.

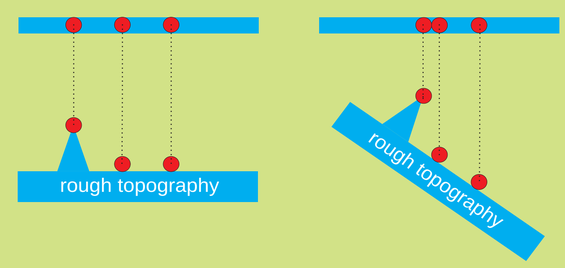
Material

- Sintered titanium foam has been used as rough and biocompatible substrate.
- Osteoblastic cells (MG-63 cell line) have been cultivated for 24 hours on the samples.

Method

Field emmision scanning electron microscopy (FESEM) with 3D-Stereoscopy

- FESEM offers the observation of cells with low beam voltage (~ 1kV) and high resolution (3.5 nm). No conductive coating as known for devices with higher beam voltage is necessary.
- Two images at distinct eucentric tilt angles (0°, 10°) are captured and the corresponding surface topography is reconstructed (using Alicona MeX Software).

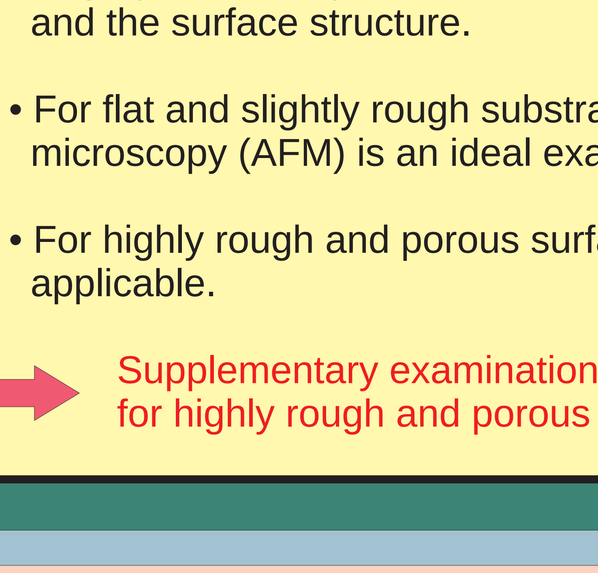


- An additional third image (20°) can be used for refining the exact tilt angle, which is the most sensitive parameter concerning the reconstruction error.

→ 3D topography of rough surfaces with high resolution of details

Substrate characterization

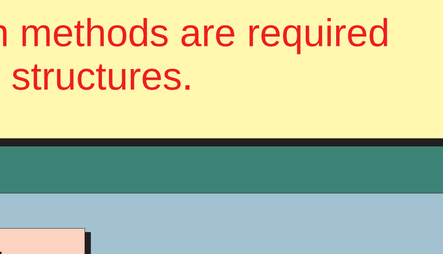
After the reconstruction, surface information is avaiable as 3D-height-matrix and additional parameters and profiles can be obtained from it.



Reconstructed 3D model of the rough cell substrate (sintered titanium particles)

Parameter	Value
Arithmetic roughness	18.292 µm
Geometric roughness	22.41 µm
Heigth difference	140.02 µm
Fractal dimension	2.0745

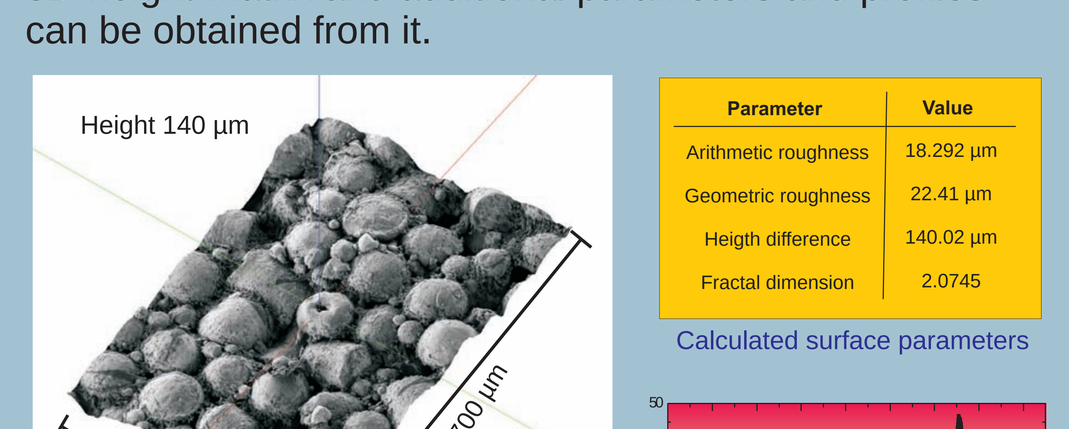
Calculated surface parameters



Surface profile along the diagonal

Cell imaging on top of the structure

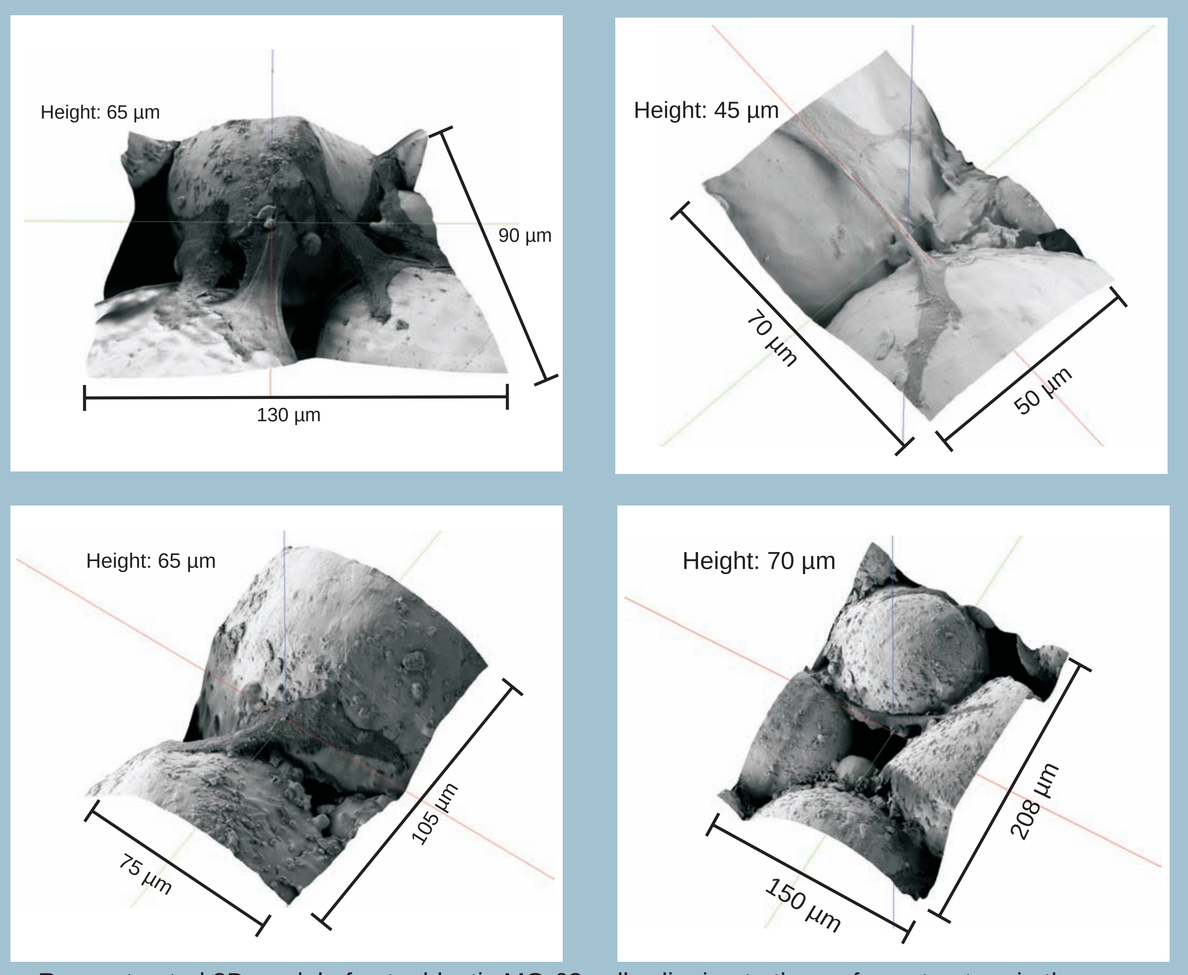
- Osteoblastic cells adapt their shape to the structure.



Osteoblastic cell adapting to the underlying surface structure and magnification of the back.

Cell imaging in the substrate gaps

- Osteoblasts are primarily located in the crevices and cling to the surface structure.
- Cells are flat compared to the substrate structure and can be resolved in detail by this method. High depth-of-focus opens the possibility to observe small details on rough structures.



Reconstructed 3D model of osteoblastic MG-63 cells clinging to the surface structure in the gaps

Conclusion

FESEM in combination with 3D-Stereoscopy is a suitable method for topography-measurements of osteoblastic cells on highly rough surfaces.

It provides high resolution of details even on rough surfaces, but is limited to dead cells and adhesion forces cannot be measured.

Contact

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