Exploring the Innovational Potential of Biomimetics for Novel 3D MEMS

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Abstract

A novel way to describe the complexity of biological and engineering approaches depending on the number of different base materials is proposed: Either many materials are used (material dominates) or few materials (form dominates) or just one material (structure dominates). The complexity of the approach (in biology as well as in engineering) increases with decreasing number of base materials.

Biomimetics, i.e., technology transfer from biology to engineering, is especially promising in MEMS development because of the material constraints in both fields. The Biomimicry Innovation Method is applied here for the first time to identify naturally nanostructured rigid functional materials, and subsequently analyze their prospect in terms of inspiring MEMS development.

Diatoms

- Size some micrometers
- Single cellular organisms
- Reproduce via cell division
- 10 000s species, since 180 millions of years
- Under ideal conditions, within ten days the offspring of one single cell number is one billion cells → assembly line production of nanostructures!
- Nanostructured surfaces made from amorphous silicates

Table

<table>
<thead>
<tr>
<th>Functions:</th>
<th>Biologized question:</th>
</tr>
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<tbody>
<tr>
<td>Parts connected in a chain with adjustable length, movable rigid parts, hinges and interlocking devices</td>
<td>How does nature ... … provide stability to chains in turbulent environments? … optimize movable parts? … mechanically connect just single cells?</td>
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<tr>
<td>Nature’s best practices: Melosira sp., Ellipsoida arizonica and further chain building diatoms</td>
<td>Generated process/product ideas: MEMS with movable parts, 3D MEMS with movable parts, micromechanical optimization of 3D-MEMS structure</td>
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<th>Functions:</th>
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<tr>
<td>Springs, precesses</td>
<td>How does nature ... … assemble into mechanical energy? … move fluids?</td>
</tr>
<tr>
<td>Nature’s best practices: Ruridella plicata, R. philippinarum</td>
<td>Generated process/product ideas: Energy storage in MEMS, micropumps for lab-on-chip</td>
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</tbody>
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<td>Stability (reinforcement), Surface texturing, Energy dissipation</td>
<td>How does nature ... … mechanically protect viable parts? … structure surfaces?</td>
</tr>
<tr>
<td>Nature’s best practices: Selenaria exsulata</td>
<td>Generated process/product ideas: 3D MEMS</td>
</tr>
</tbody>
</table>

The Biomimicry Innovation Method

- Identify function
- Find Nature’s best practices
- Biologize the question
- Generate product ideas

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References


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