Exploring the Innovational Potential of Biomimetics for Novel 3D MEMS

Ille C. Gebeshuber[1,2,3], Herbert Stachelberger[3], Bahram A. Ganji[1,4], Dee C. Fu[1], J. Yunas[1] and Burhanuddin Y. Majlis[1]

[1] 1Universiti Kebangsaan Malaysia, Institute of Microengineering and Nanoelectronics (IMEN), 43600 UKM, Bangi, Selangor, Malaysia

[2] Institut für Allgemeine Physik, University of Technology Vienna, Wiedner Hauptstrasse 8-10/134, 1040 Vienna, Austria & AC²T research GmbH, Austrian Center of Competence for Tribology, Viktor Kaplan-Strasse 2, 2700 Wiener Neustadt, Austria

[3] TU BIONIK, Center of Excellence Bionik / Biomimetics, Institute of Chemical Engineering & University Service-Center for Transmission Electron Microscopy, University of Technology Vienna, Getreidemarkt 9/166, 1060 Wien, Austria

[4] Department of Electrical Engineering, Babol University of Technology, 484 Babol, Iran

Ille.gebeshuber@ukm.my

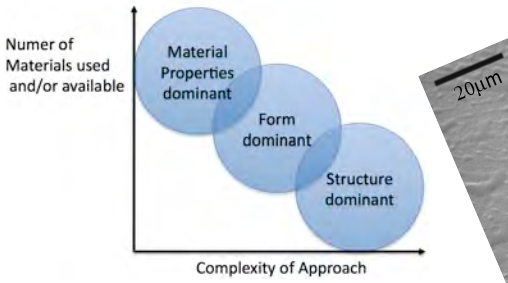
Abstract

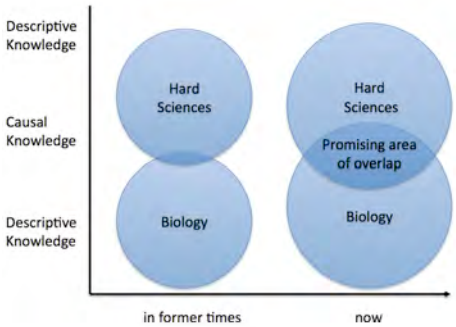
A novel way to describe the complexity of biological and engineering approaches depending on the number of different base materials is proposed: Either many materials are used (*material* dominates) or few materials (*form* dominates) or just one material (*structure* dominates). The complexity of the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

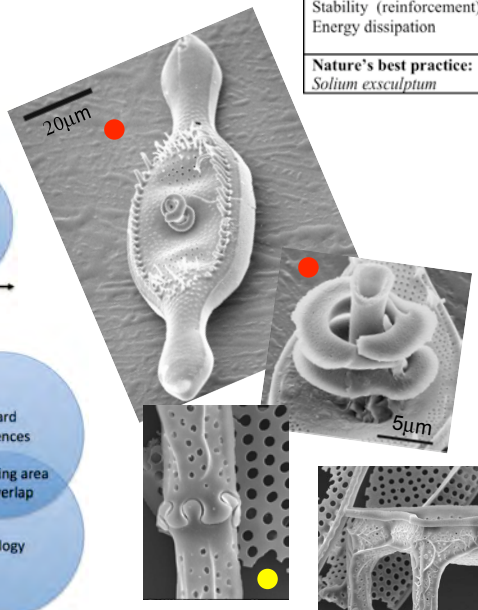
Functions: Parts connected in a chain with adjustable length, movable rigid parts, hinges and interlocking devices	**Biologized question:** **How does nature …** … provide stability to chains in turbulent environments? … optimize moveable parts? … mechanically connect hard single cells?
Nature's best practices: *Melosira sp., Ellerbeckia arenaria* and further chain building diatoms	**Generated process/ product ideas:** MEMS with moveable parts, 3D MEMS with moveable parts, micromechanical optimization of 3D-MEMS structure

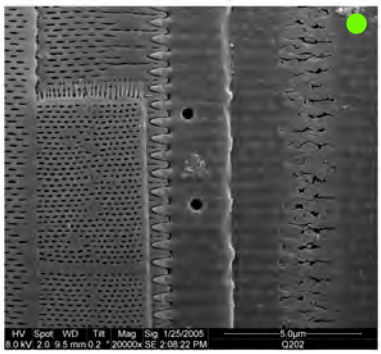
Functions: Springs, pumps	**Biologized questions: How does nature …** … reversibly store mechanical energy? … move fluids?
Nature's best practices: *Rutilaria grevilleana, Rutilaria philipinnarum*	**Generated process/ product ideas:** Energy storage in MEMS, micropumps for lab-on-a-chip

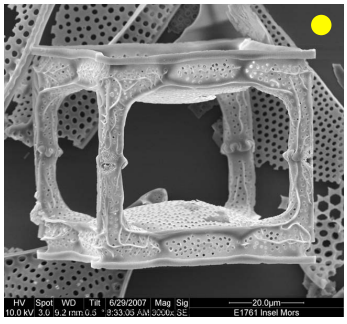
Functions: Stability (reinforcement), Surface texturing, Energy dissipation	**Biologized questions: How does nature …** … mechanically protect viable parts? … structure surfaces? … dissipate mechanical energy?
Nature's best practice: *Solium exsculptum*	**Generated process/ product ideas:** 3D MEMS

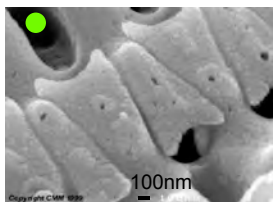












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The Biomimicry Innovation Method

* Identify function
* Find Nature's best practices
* Biologize the question
* Generate product ideas

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

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