# Osamu Tabata – DNA origami for assembling nanomachines

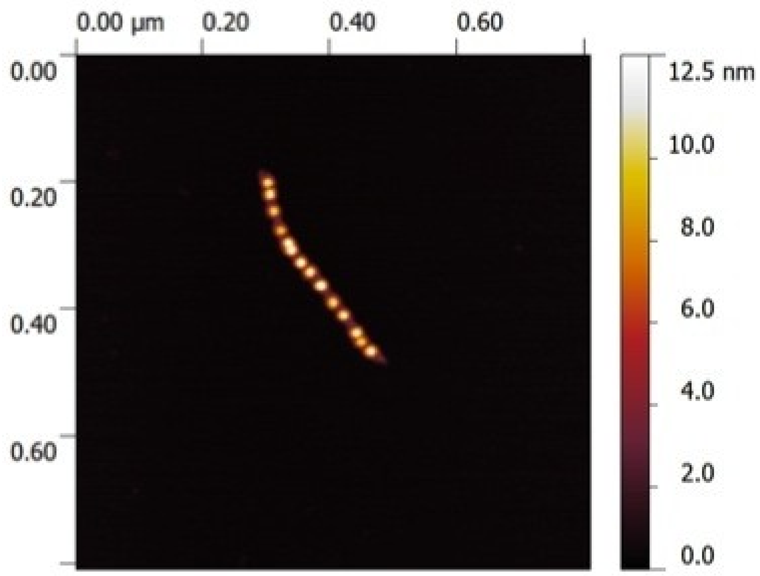
**Cells, receptor proteins, enzymes and DNA have outstanding properties. The question is, can they also be used as building blocks in computer processors, sensor systems and other micromachines in next generation microelectronics? In cooperation with his research group at the University of Kyoto and his partners in Freiburg, Prof. Dr. Osamu Tabata, microengineer and External Senior Fellow at the Freiburg Institute for Advanced Studies (FRIAS) is working on the development of a new generation of micromachines based on folded DNA molecules that is smaller, more intelligent and better than the previous generation.**

Prof. Dr. Osamu Tabata


“There is plenty of room at the bottom“, said physicist and Nobel Laureate Richard Feynman in a talk given at the annual meeting of the American Physical Society in 1959 in which he referred to the unlimited number of possibilities of manipulating and controlling things on the small scale. Around 50 years after Feynman’s classic speech, researchers around the world are increasingly focused on miniaturization on the micro- and nano scale, exploiting the intractable forces between molecules and atoms for the purpose of constructing machinery the size of a pinhead. Can these microelectromechanical systems (MEMS) or micromachines such as those found in cars, mobile telephones, video games, lab-on-a-chip applications and chemical sensors be further improved to achieve a new level of quality? Prof. Dr. Osamu Tabata, External Senior Fellow at the School of Soft Matter Research at the Freiburg Institute for Advanced Studies (FRIAS) is a pioneer of MEMS who over the last few years has become involved in what is the stuff of science fiction fantasy – the merger of machine and man.

## The future of the art of engineering

Biological elements such as cells, receptor proteins, enzymes and DNA have amazing properties: they can recognize individual molecules, conduct light energy and catalyze chemical reactions, to name just a few properties. “Can they be used as components of next-generation microelectronics systems such as computer processors, sensor systems, MEMS and other micromachines?” asks Tabata, who is a professor in the Department of Microengineering Sciences at Kyoto University in Japan. “And how can biological elements be combined with microelectronic systems?” Tabata is certain that bionanotechnology will have a huge impact on engineering in the future. Currently focused on the basic aspects, it is such visions that have driven his research from the very beginning back in the day when the term “microelectromechanical systems” had not yet been coined.



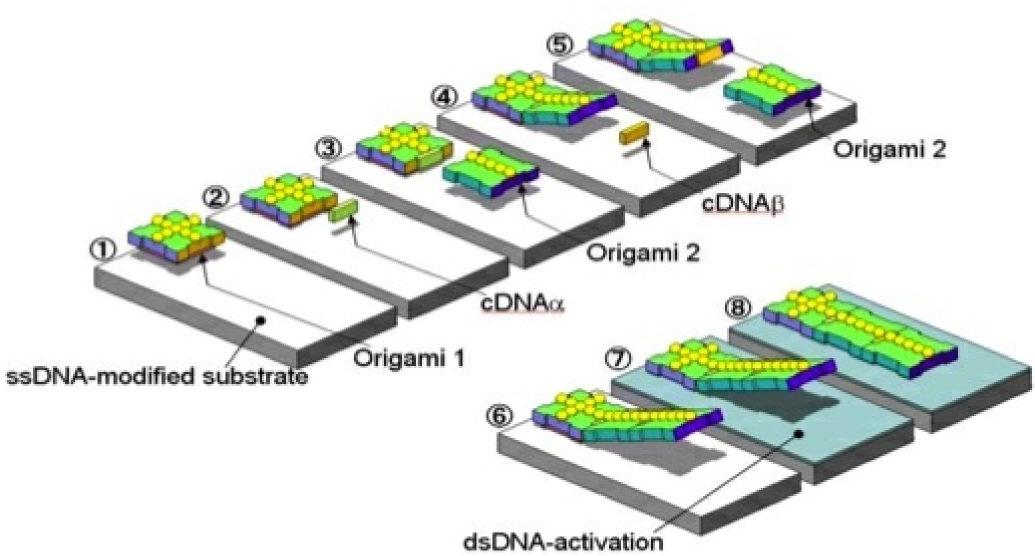

DNA nanotube 400 nm long, conjugated with 10nm-long silver nanoparticles. It can be used for guiding light rays in specific directions.


Tabata, who was born in 1956, was already extremely interested in merging technology and biology back in the early 1980s. During his master's degree studies at the Nagoya Institute of Technology, Tabata became aware of a scientific paper that reported on a microelectrode-coupled silicon plate that was able to convert nerve impulses in a patient's paralysed arm into electrical signals that controlled the movement of an artificial arm. This so fascinated him that he went on to do a doctorate on microsystems involving electrical and mechanical components at Toyota Central Research and Development Laboratories Inc. in Aichi/Japan. "This was a completely new area and young researchers were able to leave their mark," said Tabata recalling his early scientific work. During the following years, Tabata had a major influence on this area of research and contributed to establishing MEMS as a stand-alone field in the engineering sciences. MEMS, which makes use of microelectronic and micromechanic phenomena as well as the principles of microfluidics, has become an integral part of many industrial sectors.

## Bringing two worlds together

A couple of years ago, Tabata once again started a new research line combining top-down and bottom-up MEMS approaches: the top-down MEMS approach relates to the principle of miniaturizing macroscopic systems using microsystems technology and the bottom-up synthetic biology approach is based on the self-assembly of atoms and molecules. It is worth noting that although biologists are now able to construct functional sensor systems from cell components for example, very little effort had previously been made to combine these two approaches. "In my newly proposed approach, researchers can come up with many new ideas and projects, and this inventiveness is what keeps us young," said Tabata. His FRIAS research project is entitled "Configurable self-assembly of functional DNA blocks". DNA is extremely suitable for use as a building block in MEMS applications as it is both a scaffold protein and a functional element.

"We can use nanobiotechnological methods to assemble DNA molecules into functional building blocks a few nanometres in size. Due to the specific properties of the nanomaterials, these functional blocks are able to generate numerous chemical and physical reactions," Tabata explained. Tabata and his team have spent many years developing the DNA origami method which enables the researchers to fold long DNA strands into two-dimensional loops and eventually into complex three-dimensional scaffolds using many short DNA fragments. This complicated laboratory method has a decisive advantage over other methods used to produce functional nano- and microscopic particles: in contrast to an electron beam lithography system, DNA origami does not cost ten million dollars and does not fill an entire room. The DNA origami method is a relatively cheap way of producing a microscopic plate from a DNA molecule, which, when combined with metal nanomaterials, can be used to capture, transmit and emit light, to name but one example," said Tabata who is working with a group of researchers led by Jan G. Korvink, Director and Internal Senior Fellow at the School of Soft Matter Research in Freiburg.




The DNA origami method enables the researchers to fold DNA molecules into complicated scaffolds.
© Prof. Dr. Osamu Tabata

The functional diversity of a single plate is relatively limited; but the combination of several such building blocks results in complex and useful properties, including the recognition and quantification of specific molecule combinations or the transfer and processing of light energy. The latter has the potential to be used for the extremely quick transmission and processing of information in nano computer chips and replace currently used technology based on the flow of electrons, which is much slower. "This is why we are now looking for ways to combine different DNA building blocks into functional units," said Tabata who is once again very excited about working in uncharted scientific territory.

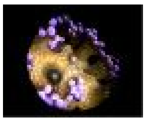
**Further information:**


Prof. Dr. Osamu Tabata
Department of Microengineering
Kyoto University
Email: tabata(at)me.kyoto-u.ac.jp

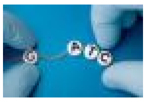

**Article**

10-Sep-2012
mn
BioRegion Freiburg


**The article is part of the following dossiers**



Molecular bionics – inspirations from the microworld for the macroworld



Engineers of life