National Aeronautics and Space Administration

Ordered Biological Nanostructures Formed From Chaperonin Polypeptides

NASA has developed a new technology that overcomes the limitations and expense of traditional approaches used in logic and memory devices. This invention provides for a method to utilize biological nanostructures, including heat shock proteins (HSP60s) from extremophilic organisms, for self-assembly of molecules onto substrates. This technology of fabricating periodic or otherwise ordered nanostructures involves the use of chaperonin polypeptides since they offer many advantages in their ability to self-assemble. The ability of the proteins to self-assemble into highly ordered structures is dependent on the environmental concentration of nucleotides and divalent cations, such as ATP (nucleotide) and magnesium. The properties of self-assembly of these proteins can be employed to selectively deposit molecules on surfaces, with an emphasis on metallic nanoparticle deposition. The order imposed by the self-assembly process can be utilized to form arrays of nanocomposites and possess long-range order not currently obtainable using traditional means of fabrication. The invention provides a hybrid bio/inorganic approach to nanophase materials organization where the functionality of proteins can be rationally engineered. These ordered arrays can be used to develop things like new semiconductor technology. This invention is available for licensing from NASA's space program to benefit U.S. industry.

Patent

This technology has been patented.
U.S. Patent No. 7,816,491
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Benefits

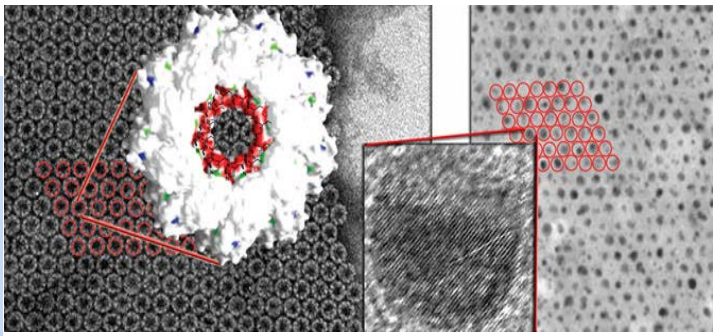
- Protein-based templates that can self assemble
- Accurate
- Nano-scale resolution
- hybrid bio/inorganic approach
- Organizational basis
- Highly ordered structure
- Can be attained on a very small material
- Diversity of the chaperonin system

Technology Details

Ordered biological nanostructures formed from chaperonin polypeptides relates to nanotemplates, nanostructures, nanoarrays, and nanodevices formed from wild-type and mutated chaperonin polypeptides and at least one nanoparticle or quantum dot. The controlled organization of inorganic materials into multi-dimensional addressable arrays is the foundation for both logic and memory devices as well as other nonlinear optical and sensing devices. Traditional techniques use lithographic patterning processes, which are approaching their practical and theoretical limits, are expensive, time consuming, and change the properties of devices. By genetically engineering a polypeptide that self-assembles into regular double-ring structures known as chaperonins, this invention teaches methods of directing the organization of nanoparticles, e.g., preformed metal and semiconductor nanoparticles, and quantum dots (QDs), into nanostructures, nanoarrays, and nanodevices. What makes chaperonins useful for the purpose of this method is that, under the proper conditions, chaperonin rings assemble themselves into higher-order structures, tailored partly by choice of chemical and physical conditions for assembly and partly by using chaperonins that have been mutated. The mutations are made by established biochemical techniques. In one embodiment, the mutant chaperonins comprise at least one mutant extremophillic HSP60 (heat-shock protein).

Commercial Applications

- Semiconductor Industry
- Biomedical
- Field emitters, sensors
- Biochips
- Optical switches, lenses, probes
- Nanoelectronic-mechanical systems
- Neural networks, nanoquantum computers
- High-density magnetic memory or storage media
- Nanopores for single-molecule DNA sequencing
- Amplifiers for telecommunications



Self-assembling biomolecules that form highly ordered structures

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