Self-assembly method for design of lattices for optical metamaterials

KEYWORDS

- ❑ NANO-TECHNOLOGY
- ❑ DNA-TECHNOLOGY
- ❑ SELF ASSEMBLY
- ❑ CRYSTALS
- ❑ PHOTONIC MATERIALS

AREA

- ❑ NANO-TECHNOLOGIES & MATERIALS

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Sapienza University of Rome 10%, Arizona State University 80%, Ca' Foscari University 10%.

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Nanotechnology applications, design of new materials, including photonic crystals

Time to Market
TRL is 4

Availability
Cession, Licensing, Research, Development, Experimentation, Collaboration.

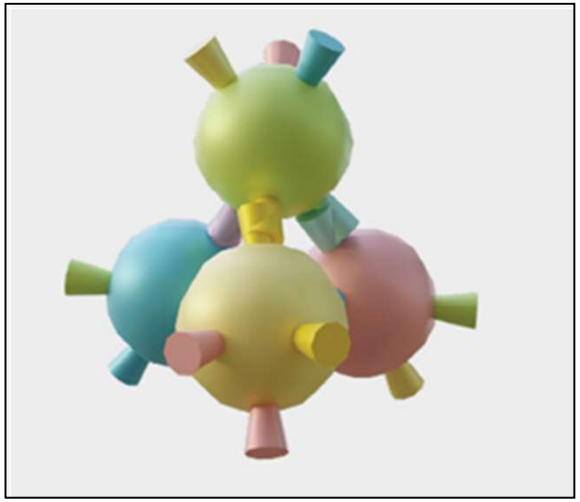


Fig.1 Patchy particle model for the building blocks, comprising 4 species and 24 individual bonds..

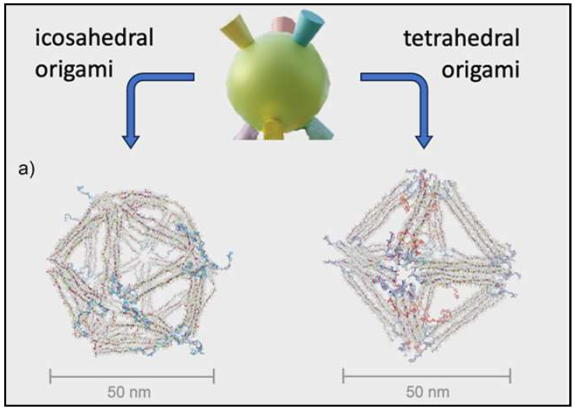


Fig.2 oxDNA coarse-grained representation of the DNA origami: isocosahedral origami on the left, and tetrahedral origami on the right. .

Abstract
This invention pertains to the design of photonic metamaterials using a novel approach based on DNA nanostructures. Guided by numerical simulations, this method enables the precise positioning of optical particles within a 3D pyrochlore lattice (tetrastack) in the UV/visible domain. The use of numerical simulations and experimental work makes it feasible to self-assemble DNA nanostructures to create the target lattice. The patent covers the design of the "tetrastack" crystal, with significant applications in light manipulation, photonic bandgaps, waveguiding, optical devices, photovoltaics, and thermal control.

Technical Description

Our invention concerns a method based on the self-assembly of DNA origami structures for the design of photonic metamaterials. This novel approach exploits DNA nanostructures that enable the self-assembly of optical particles within a three-dimensional pyrochlore lattice known as a tetrastack, operating in the UV and visible spectra. Object of innovation solves the Boolean satisfiability design problem through constrained optimization theory. The versatility of functionalized DNA enables nanoscale placement, opening up new perspectives in the developing of metamaterials.

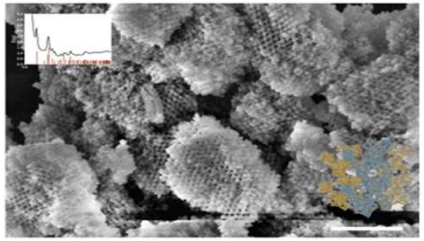
Technologies & Advantages

The patent covers the crystal design "tetrastack," a photonic crystal with cavities arranged in a three-dimensional cubic diamond structure lattice. This crystal is of considerable importance in the field of nanotechnology. Our innovation is characterized by several advantages suche as, the use of origami DNA nanostructures as the basis for self-assembly of crystal structures. Moreover, the solution allows for precise control of the positioning of optical particles, thus enabling, the creation of the "tetrastack" crystal. In addition, the ability to design and fabricate DNA nanostructures specifically for the formation of the target lattice ensures the stability and reliability of the assembly as well as the integration of different materials.

Applications

The proposed solution can be applied in several sectors:
Light control: the "tetrastack" crystal offers precise control of optical properties, allowing light to be manipulated at the nanoscale.

- Photonic Forbidden Band: by creating a "photonic forbidden band," the crystal allows specific wavelengths to be filtered or blocked, making it ideal for optical devices such as filters and selective mirrors.
- Waveguide: the crystal acts as a waveguide, enabling efficient transport of optical signals in devices and integrated circuits.
- Optical and Photovoltaic Devices: it is critical in the design of devices such as photonic crystal lasers, light sensors, optical modulators, and high-speed data transmission systems.



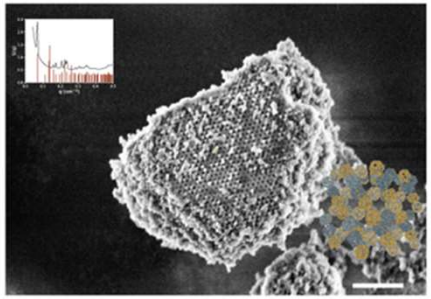


Fig.3 SEM images of the pyrochlore crystals, together with their scattering spectra

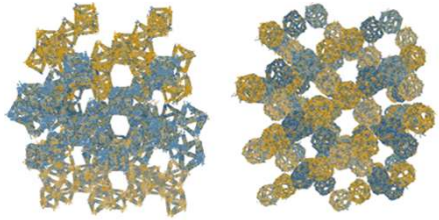


Fig.4 oxDNA coarse-grained representation of the pyrochlore lattice obtained from the tetrahedral origami (on the left) and icosahedral origami (on the right)

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