Metabolic Insertion of Germanium and Titanium Nanostructures into Diatom Biosilica

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Résumé

Many microorganisms have a unique capacity to create nanostructures with a hierarchical order and complexity that exceeds the capabilities of current nanotechnology. A prime example is the diatoms, a class of single-celled, photosynthetic algae that biologically fabricate intricate shells of biosilica called frustules ordered at the nano and microscales. We have harnessed the biomineralization capacity of diatoms to make nanopatterned metal oxide semiconductor materials metabolically doped with germanium (Ge) or titanium (Ti) that possess unique optical and electronic properties for device applications. A two-stage cell culture process is used to metabolically insert nanoscale titanium or germanium oxides into the photonic crystal-like structure of the diatom biosilica. By controlling the timing of Si and Ge (or Si and Ti) addition relative to the timing of the diatom cell division cycle, Ge or Ti rich nanophases can be directed to specific substructures within the diatom frustule. The metabolic insertion of Ge-oxide rich nanophases into the diatom biosilica, followed by thermal annealing to activate the Ge-oxide luminescent centers, rendered the diatom biosilica highly photoluminescent, with emission centered at blue wavelengths. The incorporation of biogenic Ti-oxide nanophases into the diatom biosilica, followed by thermal annealing in air to activate the amorphous Ti-oxide to the semiconducting anatase TiO2 form (Fig. 1). These efforts illustrate how engineered cultivation systems for bio-mineralizing microorganisms can be used to fabricate interesting nanostructured metal oxide materials with opto-electronic properties.

Mots-Clés: biosilica, diatom, germanium, nanostructure, titanium

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