Nanoscopic Patterned Materials

Scalable Nanomanufacturing Method Using Atomic Layer Deposition

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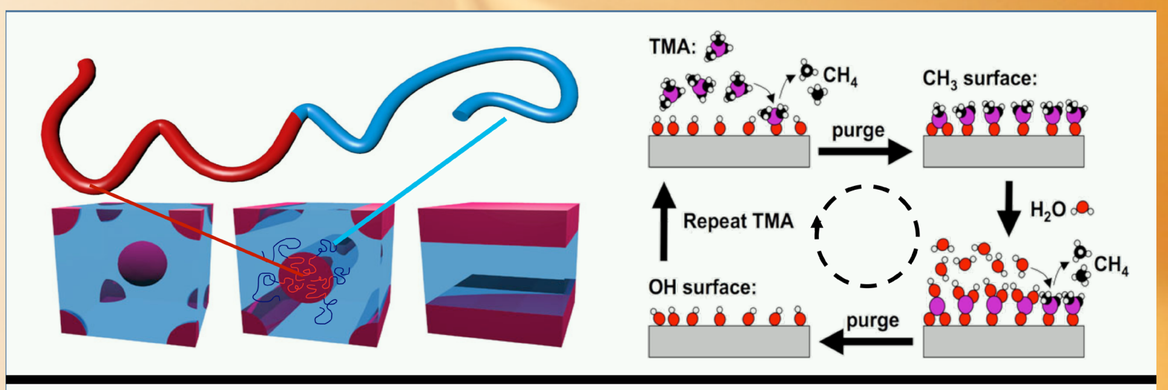
Opportunity

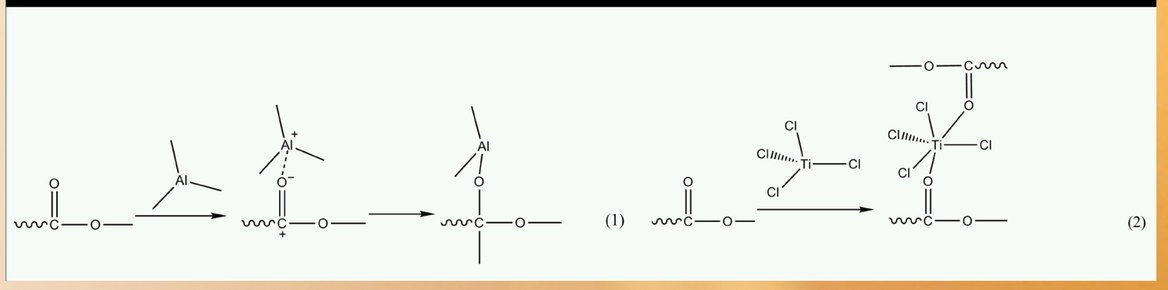
Nanomaterials could satisfy many of our nation's energy needs with environmentally friendly and sustainable technologies that lead to improvements in energy production, energy storage, and energy efficiency. Scalable manufacturing methods for producing ordered 2-D and 3-D nanoscale materials with molecule-level precision are necessary to enable these technologies.

Solution

The confluence of atomic layer deposition (ALD) and block copolymer (BCP) lithography provides a promising technique to engineer materials at the molecular-level and address many potential applications including photovoltaics, catalysis, and lithium batteries.

Argonne researchers have fabricated ordered, nanostructured materials with precisely tuned dimensions by a well-controlled molecule-assembly method combining ALD and BCP templates. This interdisciplinary research effort involves staff and facilities in the Energy Systems Division and the Center for Nanoscale Materials.

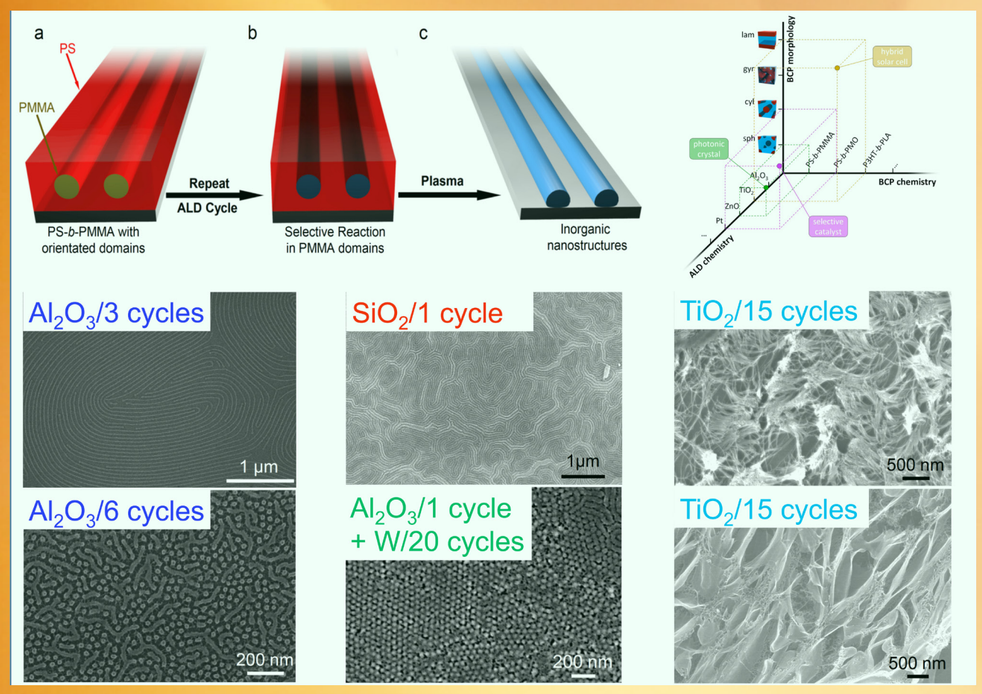




What We've Achieved

The Argonne team has synthesized 2-D/3-D ordered materials of Al_2O_3, TiO_2, ZnO, W, SiO_2 through a novel process involving two key steps:

1. Selective and self-limited coordination reaction between metal precursors and one domain of BCPs
2. Selective and self-limited growth of materials by ALD with coordinated metal precursor as the nucleation site



Benefits

- Self-limited molecule assembly provides uniformity across large areas
- Dimensions of nanomaterials can be adjusted by ALD and BCPs
- Custom-engineered nanomaterials are possible
- Ordered 2-D and 3-D nanostructures can be synthesized

Future Work

- Extend this technique to other materials
- Measure the properties of BCP/inorganic hybrid materials
- Initial target applications: photocatalysis and photovoltaics

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