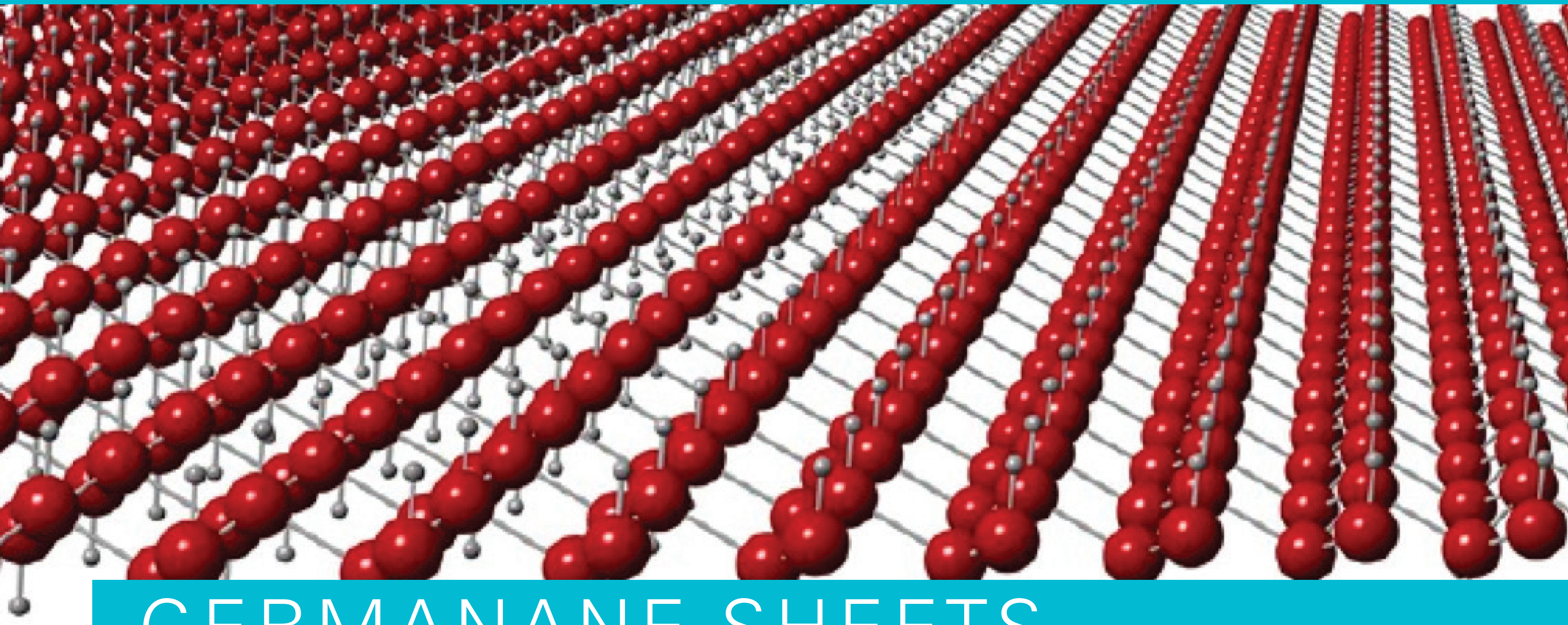

GERMANANE SHEETS

Windl, colleagues study properties of one-atom-thick, layered materials

Just one decade ago, researchers first isolated graphene, a carbon film only one atom thick – essentially a semi-metallic material so thin that it presents only two measurable dimensions, length and width. Despite its lack of depth, graphene is extremely strong and superconductive; scientists and manufacturers already have filed patents for various applications that leverage the remarkable properties of this material.

"Graphene-based materials have been proposed for many applications, ranging from transparent conductors to thermal interface materials to certain transistor-like devices," said Wolfgang Windl, Ph.D., professor of Materials Science Engineering at The Ohio State University. "Graphene's success has shown not only that it is possible to create stable, single-atom-thick sheets from a crystalline solid, but that these materials have fundamentally different properties than the parent material."

Windl and experimental collaborator Joshua Goldberger, Ph.D., from Ohio State's Chemistry department, observed that there exists an entire periodic table of crystalline solid-state materials from which scientists may be able to create single-atom or few-atom polyhedral thick 2-D layers, with each material having different electronic, mechanical and transport properties. However, most of the layered materials studied to date have been composed of neutral or ionic layers and lack the ability to modify the surface properties of industrial materials.

As single-layer materials are entirely surface area, their properties and reactivity profoundly depend on the underlying substrate, the local electronic environment and mechanical deformations. Windl's group predicted, based on density-functional calculations, that single layers of silicon, germanium and other similar materials terminated with hydrogen or other functional groups should have stability, tunable electronic properties by modifying the terminating molecules and record-breaking conductivity in the semiconductor world.

Goldberger's research group then mechanically deposited germanane sheets as single and few layers onto silicon dioxide/silicon surfaces. Subsequently, Windl's group predicted that substituting the hydrogen with methane molecules, the material should have strongly different optical properties, which Goldberger's successful synthesis of the material confirmed.

"We now have created gram-scale, millimeter-sized crystallites of hydrogen-terminated germanane – a single-atom layer of the element germanium – and have characterized for the first time their long-term resistance to oxidation and thermal stability, a necessary prerequisite for any practical application," Windl said. "This material represents a new class of covalently terminated graphane, a tunable relative of graphene that has great potential for a wide range of optoelectronic and sensing applications. This opens a new world full of opportunities significantly beyond graphene."

Above: Windl and Goldberger synthesized for the first time millimeter-scale crystals of a hydrogen-terminated germanium multilayered graphane analogue (germanane, GeH) from the topochemical deintercalation of CaGe2.

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