Researchers create 'nanoflowers' for energy storage, solar cells

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The GeS "nanoflowers" have petals only 20-30 nanometers thick, and provide a large surface area in a small amount of space. The structures hold promise for next-generation energy storage devices and solar cells. Credit: Linyou Cao, North Carolina State University

(Phys.org)—Researchers from North Carolina State University have created flower-like structures out of germanium sulfide (GeS) – a semiconductor material – that have extremely thin petals with an enormous surface area. The GeS flower holds promise for next-generation energy storage devices and solar cells.

"Creating these GeS nanoflowers is exciting because it gives us a huge surface area in a small amount of space," says Dr. Linyou Cao, an assistant professor of materials science and engineering at NC State and co-author of a paper on the research. "This could significantly increase the capacity of lithium-ion batteries, for instance, since the thinner structure with larger surface area can hold more lithium ions. By the same token, this GeS flower structure could lead to increased capacity for supercapacitors, which are also used for energy storage."

To create the flower structures, researchers first heat GeS powder in a furnace until it begins to vaporize. The vapor is then blown into a cooler region of the furnace, where the GeS settles out of the air into a layered sheet that is only 20 to 30 nanometers thick, and up to 100 micrometers long. As additional layers are added, the sheets branch out from one another, creating a floral pattern similar to a marigold or carnation.

"To get this structure, it is very important to control the flow of the GeS vapor," Cao says, "so that it has time to spread out in layers, rather than aggregating into clumps."

GeS is similar to materials such as graphite, which settle into neat layers or sheets. However, GeS is very different from graphite in that its atomic structure makes it very good at absorbing solar energy and converting it into useable power. This makes it attractive for use in solar cells, particularly since GeS is relatively inexpensive and non-toxic. Many of the materials currently used in solar cells are both expensive and extremely toxic.

More information: The paper, "Role of Boundary Layer Diffusion in Vapor Deposition Growth of Chalcogenide Nanosheets: The Case of GeS," is published online in the journal *ACS Nano*.
pubs.acs.org/stoken/nanotation … bs/10.1021/nn303745e

Abstract
We report a synthesis of single crystalline two-dimensional (2D) GeS nanosheets using vapor deposition processes, and show that the growth behavior of the nanosheet is substantially different from those of other nanomaterials and thin films grown by vapor depositions. The nanosheet growth is subject to strong influences of the diffusion of source materials through the boundary layer of gas flows. This boundary layer diffusion is found to be the rate-determining step of the growth under typical experimental conditions, evidenced by a substantial dependence of the nanosheet's size on diffusion fluxes. We also find that high quality GeS nanosheets can only grow in the diffusion-limited regime, as the crystalline quality substantially deteriorates when the rate-determining step is changed away from the boundary layer diffusion. We establish a simple model to analyze the diffusion dynamics in experiments. Our analysis uncovers an intuitive correlation of diffusion flux with the partial pressure of source materials, the flow rate of carrier gas, and the total pressure in synthetic setup. The observed significant role of boundary layer diffusions in the growth is unique for nanosheets. It may be correlated to the high growth rate of GeS nanosheets, ~3-5 [micrometer]/min, which is one order of magnitude higher than other nanomaterials (such as nanowires) and thin films. This fundamental understanding on the effect of boundary layer diffusions may generally apply to other chalcogenide nanosheets that can grow rapidly. It can provide useful guidance for the development of general paradigms to control the synthesis of nanosheets.

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