SCIENTIFIC COMMUNITY

A gift to the Queen of Carbon: A special collection in honor and memory of Mildred Dresselhaus

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Progress in nanoscience and nanotechnology has led to seismic changes and developments in the past few decades. New discoveries and enabling technologies have affected everything from transportation and textiles to agriculture, energy, health, and national security.

Mildred Dresselhaus, the first woman ranked Institute Professor at MIT, devoted her entire career to the study of carbon-based nanomaterials (such as fibers, nanotubes, C_{60}, and graphene). This research earned her the title of the "Queen of Carbon." Her pioneering work was eclipsed only by the breadth of recognition she received. In 2014, then President Barack Obama awarded Millie the Presidential Medal of Freedom for her significant accomplishments and contributions to nanoscience and nanotechnology. Her research, commitment to gender equity in science and engineering, and her sustained efforts to mentor other women inspired many around the world.

The special collection (https://www.sciencemag.org/collections/advances/dresselhaus) is a gift from some of her former collaborators and colleagues to honor Millie and her ground-breaking accomplishments. The 13 papers in the collection cover different areas of carbon-based nano- and multifunctional materials.

TOWARD CONTROLLED SYNTHESIS

Chemists and materials scientists continue to search for controlled synthesis of perfect nanomaterials. Gao *et al.* (2018) report the facile synthesis of an ultrathin single-crystalline graphdiyne film on graphene using a solution-phase van der Waals epitaxial strategy. This approach led to the synthesis of one- or few-layer graphdiyne(s) and the discovery of its ABC stacking structure. Cao *et al.* (2020) report the successful realization of highly crystalline and large-area thin films of 2D transition metal nitrides (TMNs) using in situ chemical conversion. This general approach can be easily extended to obtain other TMNs (e.g., Mo_5N_6, W_5N_6, and TiN).

TOWARD ADVANCED CHARACTERIZATION TOOLS

Identifying structures and measuring behaviors at the nanoscale are critical to a variety of processes. An *et al.* (2019) propose a strategy to obtain a new statistical understanding of the catalytic dynamics in growing single-walled carbon nanotubes using atomic-resolution scanning transmission electron microscopy (STEM). This work highlights large-area and single-particle structure identifications and dynamic evolution of catalysts. Hsu *et al.* (2020) demonstrate the development of strain-induced giant pseudo-magnetic fields and global valley polarization by scanning tunneling microscopy/spectroscopy (STM/STS). Their report also discusses nanoscale strain engineering of graphene films, the corresponding topographic and spectroscopic studies, and valleytronic/spintronic devices. Reynolds *et al.* (2019) provide a new tool for visualizing chemical reactions and biomolecules with a 2D nanomaterial screen. The observed sensitivity and spatial resolution are much superior to other reported techniques. Timp *et al.* (2019) review alternative tools for the identification of whole proteins that can be used to displace conventional mass spectrometry. Timp and colleagues identify five alternatives including transcriptome sequencing, cellular indexing of transcriptomes and epitopes by sequencing, fluorescent "protein fingerprinting," 5D fingerprinting with a nanopore, and sequencing denatured unfolded protein with a nanopore.

TOWARD DISCOVERING INTRINSIC PROPERTIES

Unraveling the intrinsic properties of materials will enable us to design novel ones with the desired properties needed for incorporating them in enabling technologies and addressing societal needs. Luckyanova *et al.* (2018) found the phonon localization phenomenon as a new path toward engineering phonon thermal transport. This was not only observed experimentally for GaAs/AlAs superlattices with ErAs nanodots but also supported by theoretical calculations. Zheng *et al.* (2019) report the first material (Li-doped MnTe) with technologically meaningful thermoelectric energy conversion efficiency from a spin-caloritronic effect. Different electrical and transport properties at varying temperatures are characterized. Zhu *et al.* (2019) provide a route for discovering promising thermoelectric materials. By quantifying the relationship between the asymmetrical thermoelectric performance and the weighted mobility ratio, promising thermoelectric materials such as n-type ZrCoBi-based half-Heuslers can be predicted and soon be prepared.

Golam Rosul *et al.* (2019) describe thermionic cooling across van der Waals structures and obtain the Seebeck coefficient, electronic structure, and transport properties of gold-graphene-WSe_2-graphene-gold, both computationally and experimentally.

TOWARD MULTIFUNCTIONAL MATERIALS AND APPLICATIONS

Materials with various functionalities serve many industries and new enabling technologies from wearable sensors and health monitors to flat panel displays, solar panels, and radiative cooling devices. Polat *et al.* (2019) demonstrate a new class of flexible and transparent wearables based on graphene sensitized with semiconducting quantum dots. These graphene-based wearable devices can monitor various health signs noninvasively. Also, in the field of wearable devices, He *et al.* (2019) report a silk fabric–derived carbon textile for simultaneous detection of six health-related biomarkers. The group also describes an integrated sensing patch for wireless, on-body, and real-time sweat analysis. Leroy *et al.* (2019) characterize various properties and test the passive radiative cooling performance of polyethylene aerogel, which Wang's laboratory developed for radiative cooling.

As the papers in this collection demonstrate, the theme of Richard Feynman's 1959 talk entitled "There's plenty of room at the bottom" is as relevant today as it was 60 years ago. We are grateful to all the authors and former colleagues of Millie for their insightful contributions honoring her life and dedication to science. We hope that readers from diverse fields of science and engineering across the world will enjoy this small, representative collection of papers and that these excellent articles may serve as an inspiration for some to continue the legacy of Millie "Queen of Carbon." Last, we express our sincere thanks to all former and present editorial staff members of *Science Advances* for their hard work and support.

–Zakya H. Kafafi and Jin Zhang

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