Coal Could Play Vital Role in Next-Generation Electronic Devices, Study Suggests

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As modern society shifts away from older technologies and carbon-emitting energy production, experts continue to look for ways to reimagine traditional sources and align them with sustainable goals. Coal, which has fueled the world for several decades, has been a significant candidate for utilizing ancient materials in high-tech ways.

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Coal as a Traditional Source of Energy

Coal is a combustible black or brownish-black sedimentary rock that contains large amounts of carbon and hydrocarbons. It comes from the remains of plants that died about 100 to 400 million years ago. For this

reason, it is classified as a nonrenewable energy source since it takes millions of years to form. It is an abundant energy source in the US, and its industrial significance is also evident in various countries.

Humans began using coal in the 1800s to heat their homes, run trains and ships, and fuel factories to make iron and steel. In modern times, coal is burned to make electricity. Despite its usefulness, however, coal contributes to climate change as it is used as a fossil fuel.

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Unlocking New Potential for Coal

A joint research effort from Taiwan Semiconductor Manufacturing Company, Oak Ridge National Laboratory, the National Energy Technology Laboratory (NETL), and the University of Illinois Urbana-Champaign has found a way to reconsider and reevaluate the economic role of coal. The researchers have discovered an innovative use of coal in producing advanced electronic devices. The results of their study are reported in the paper "Ultrathin quasi-2D amorphous carbon dielectric prepared from solution precursor for nanoelectronics".

While coal is usually considered dirty and bulky, the processing techniques developed by the research team can transform it into high-purity materials that are just a few atoms thick. According to University of Illinois materials science and engineering professor Qing Cao, coal's unique atomic structures and properties are ideal for making some of the smallest electronic devices with state-of-the-art performance.

In this study, experts at NETL first converted coal char into nanoscale carbon disks called "carbon dots." Researchers from the University of Illinois demonstrated that these disks can be connected to form atomically thin membranes, which can be applied in two-dimensional transistors and memristors.

Cao and his colleagues used coal-derived carbon layers as the gate dielectric in two-dimensional transistors built on the semimetal graphene or semiconductor molybdenum disulfide. This enables a device operating speed that is two times faster with lower energy consumption. Like other atomically thin materials, the carbon layers derived from coal do not possess "dangling bonds" or electrons that are not associated with any chemical bond. These sites alter their electrical properties by working effectively as "traps," which slow the transport of mobile charges and the transistor switching speed.

Applying coal in memristors found that adopting ultrathin coal-derived carbon layers as the insulator enables the fast formation of conductive filaments with low energy consumption. Additionally, the atomic size rings in the carbon layers confine the filament for enhanced device operations for better data storage fidelity and reliability.

Over the coming years, the University of Illinois plans to continue working with the National Energy Technology Laboratory to develop a production process for these coal-derived materials. They hope this will

pave the way for a remarkable and eco-friendly use of coal in microelectronics.

https://youtu.be/g_-folZljZ4

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