Researchers compare energy consumption during extraction and synthesis of one diamond carat

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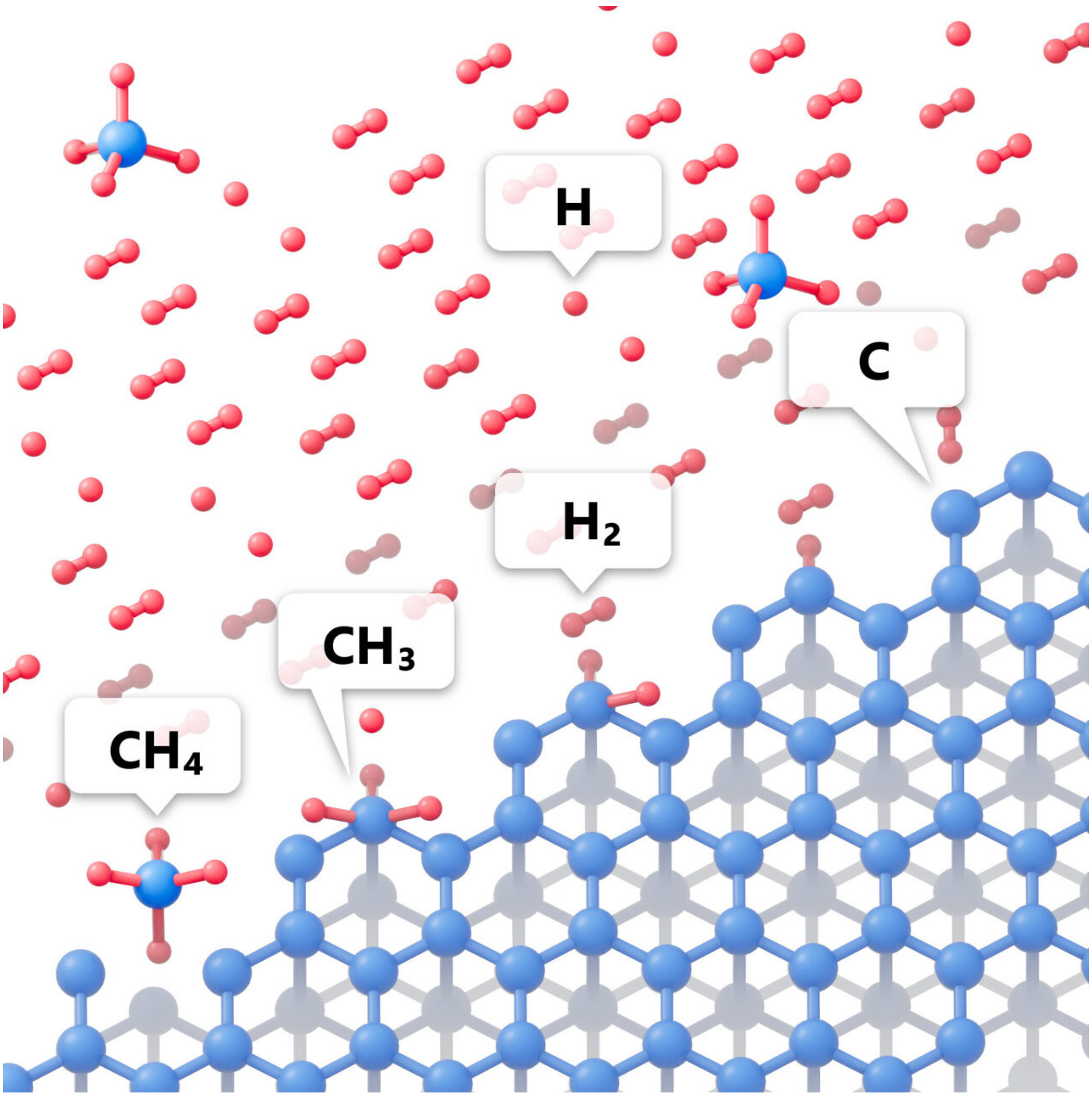

Diagram of M-CVD process: The dissipation of methane (CH_4) into methyl (-CH_3) and atomic hydrogen (H), the capture of a methyl group by the diamond cell, and further dehydrogenization. Credit: V. Zhdanov

Researchers from HSE University, RAS, and Skoltech have compared actual specific energy consumption in the production of diamonds using traditional (mining) and innovative (synthesis) methods. Depending on the technology, 36 to 215 kWh of energy is consumed to produce a 1 carat diamond. It turned out that not all diamond synthesis technologies surpass extraction methods in terms of energy efficiency. The results of the study were published in the journal *Energies*.

Energy consumption in the production of diamonds serves as an indicator of overall production efficiency: The less energy is consumed, the less direct and indirect specific environmental burden the process brings about.

Energy costs are one of the main burdens in diamond production. Diamond mining in Eastern Siberia and South Africa, the sites analyzed in the paper, does not go beyond the range of 96-150 kWh per carat, which roughly corresponds to the median energy efficiency.

Researchers from HSE University, the Institute of Oil and Gas Problems of the Siberian Branch of the Russian Academy of Sciences and Skoltech analyzed specific energy consumption data for diamond production. It was based on reports provided by the leading diamond producers—Alrosa and De Beers—as well as on the data taken from laboratory studies of synthesis processes.

"Thanks to the up-to-date data, we were able to observe the overall dynamics, which is a reduction in energy consumption. At the same time, the hypothesis that the synthesis of diamonds is priori a less environmentally burdensome means of producing diamonds has not been confirmed—at the very least, diamond mining rivals the widespread technology of chemical vapor deposition (CVD) in terms of energy efficiency," says Dr. Vladislav Zhdanov, HSE Professor and the article's author.

The researchers assume that depending on the technology, 36 to 215 kWh of energy must be consumed in order to produce a 1 carat diamond. When synthesizing diamonds by the means of the High-Pressure-High-Temperature method (with an open cooling circuit), the most common one today, energy consumption amounts to only about 30 kWh per carat, while, when synthesizing diamonds by chemical vapor deposition, electricity consumption can exceed 200 kWh. In other words, the energy appetites of diamond synthesis methods differ significantly. At the same time, the method of chemical vapor deposition, despite its high specific energy intensity, allows one to obtain diamonds with special properties, which are particularly useful in quantum physics and thermonuclear energy.

"In addition to the two above-mentioned synthesis technologies, there are at least two other methods of obtaining diamonds in laboratory conditions—detonation and cavitation, the specific energy consumption of which was not considered in our study," says Professor Zhdanov. "If we try to determine the favorites in the race of synthesis technologies, then my bet is on chemical vapor deposition and cavitation. I believe that these technologies have the maximum potential."

The researchers believe that both methods of diamond production, mining and synthesis, have significant potential to increase their energy efficiency, which will ultimately have positive impact on the whole industry.

The results of the study can be of significant use to both diamond producers and those end users who are interested in the environmental footprint of the products they purchase.

More information: Vladislav Zhdanov et al, A Comparative Analysis of Energy and Water Consumption of Mined versus Synthetic Diamonds, *Energies* (2021). DOI: 10.3390/en14217062

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