Introducing Hyper-Cold Fusion

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Abstract

Hyper-cold fusion is an innovative nuclear fusion approach that exploits the unique electronic properties of 2D materials. Unlike conventional cold fusion using hydrogen-occluded metals, our method operates on graphene surfaces under elevated gas pressures while maintaining low-energy states. The mechanism relies on graphene's ability to emit terahertz radiation, creating an excited electron-rich environment where plasmons with Fermi velocities of 6000 km/s interact with hydrogen nuclei. High-pressure hydrogen gas on graphene surfaces shows enhanced mobility compared with hydrogen in conventional systems, increasing the probability of fusion interactions. The proposed electron capture mechanism involves ground-state hydrogen atoms interacting with graphene plasmons, potentially enabling fusion reactions on the material surface. This approach addresses fundamental limitations of traditional cold fusion by providing a more controlled and potentially scalable fusion pathway through the strategic utilization of 2D material properties.

1. Introduction

In 1989, two electrochemists, Fleischmann and Pons, reported that electrolysis with palladium and deuterium generated nuclear energy in the form of heat [1]. Since then, cold fusion research has been conducted by numerous experts worldwide. Although cold fusion has not gained widespread attention and acceptance in the mainstream scientific community, significant developments have highlighted the potential of cold fusion in recent years. In 2022, the US Department of Energy began funding cold fusion projects as part of its Exploratory Topics program, and several academic institutions have received funding to conduct cold fusion research [2].

My research lab, Nano Fusion Design, was established with a clear mission: to harness the potential of graphene materials for nuclear fusion. While reviewing past experiments, I discovered that excess heat has not been observed for graphite powder and hydrogen under pressures below 1 MPa [3], but excess heat has been confirmed for the hydrogenation of carbon at 5.4 MPa [4]. The pressure threshold of 5.4 MPa appears to be critical for achieving sufficient hydrogen density on carbon surfaces to enable electron capture mechanisms [5] and support efficient fusion reactions. At lower pressures, the hydrogen coverage is insufficient to obtain fusion reactions with enough energy to power a generator. Additionally, excess heat has been achieved using terahertz pulses [6]. Building on these observations, I am planning further experiments using terahertz-emitting graphene [7] and borophane—a material with a high hydrogen density [8]. These materials may facilitate the development of practical cold fusion systems.

2. Design of Hyper-Cold Fusion

Hyper-cold fusion represents a significant enhancement in traditional cold fusion. Whereas traditional cold fusion relies on 3D metals to absorb hydrogen in near-vacuum conditions, hyper-cold fusion operates on 2D material surfaces under high-pressure gas environments, giving rise to the term 'hyper.' This innovative approach leverages the unique properties of 2D materials like

graphene and borophane to achieve fusion reactions more efficiently. Fig. 1 illustrates how 2D materials are revolutionizing the cold fusion landscape, contrasting traditional methods with this ground-breaking new approach.

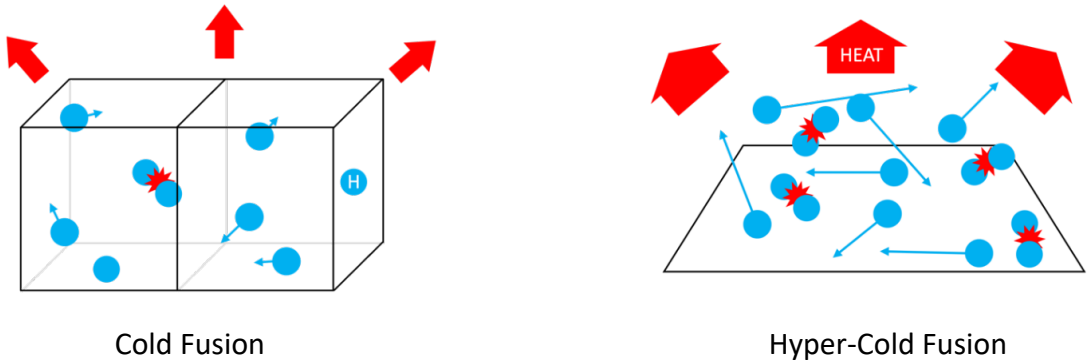

Figure 1. Conceptual comparison of the energy density and efficiency in cold fusion vs. hyper-cold fusion.

In addition to graphene, the proposed system relies on borophane, a 2D borohydride sheet composed of boron and hydrogen atoms with an H:B ratio of 1:1 [8]. When heated above 200 °C, borophane releases hydrogen atoms from its surface. This temperature-dependent desorption process enables proton-boron fusion reactions through electron capture mediated by graphene. By irradiating the graphene-borophane mixture with electromagnetic waves, excess heat or electrical power may be generated under rigorously controlled conditions. Instead of using only high-pressure hydrogen gas as a fuel, this approach makes it easier to perform experiments, improves fuel mobility, and enhances the shelf life.

A three-step reaction pathway is hypothesized: (1) borophane releases hydrogen at 200 °C; (2) these hydrogen atoms collide with the high-speed electrons in graphene, producing neutrons; and (3) these neutrons fuse with boron to form lithium and helium, releasing 2.79 MeV of energy per reaction.

1. Hydrogen desorbs from borophane heated above 200 °C.

2. Hydrogen collides with fast electrons on graphene and converts to neutrons.

   $p + e^- \rightarrow n + \nu_e$

3. Neutrons fuse with boron and convert to lithium and helium, releasing nuclear energy.

   $n + {}^{10}B \rightarrow {}^{7}Li + {}^{4}He$ ($Q \approx 2.79$ MeV)

Theoretically, 1 g of borophane can yield thermal energy equivalent to burning 100 kg of oil—enough to power a small home for months without producing problematic nuclear waste or radiation.

3. Experimental Setup

A schematic of the experimental setup is shown in Fig. 2. A mixed powder of graphene and borophane is enclosed in a 100 mL pressure-resistant chamber. The chamber is evacuated to a vacuum level ranging from 1 Pa to 150 MPa. The outer wall is heated to several hundred °C using an electric heating wire, causing borophane to release hydrogen gas. Under these conditions, hydrogen exists as a supercritical fluid, a state where the distinction between liquid and gas phases disappears. This hydrogen is expected to interact with graphene and boron, initiating fusion reactions through electron capture. The detection of excess heat or fusion byproducts (e.g., alpha particles) is necessary to validate the proposed mechanism.

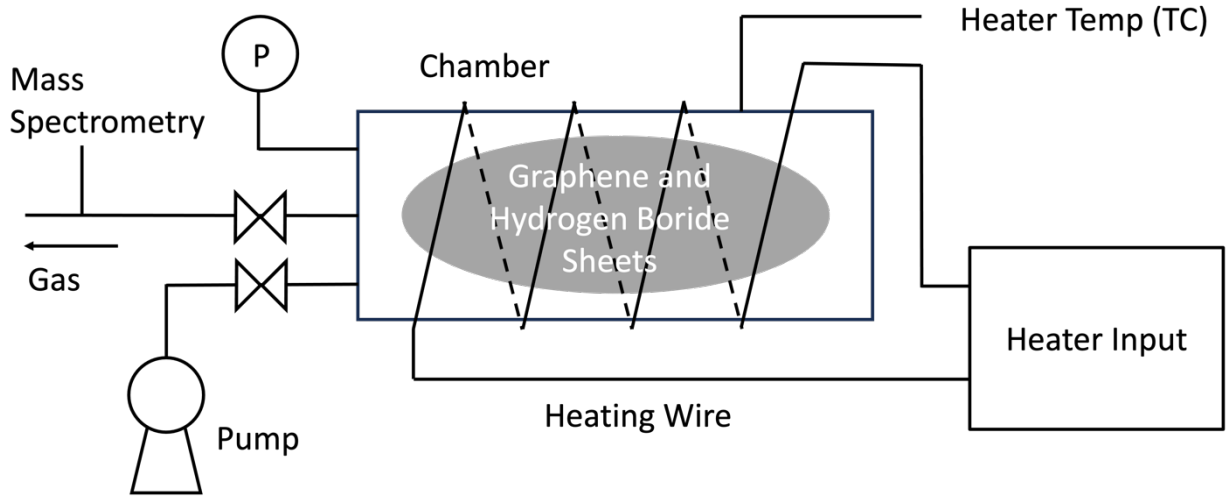

Figure 2. Schematic of the experimental setup.

The prototype chamber is made of a high-performance alloy, namely Hastelloy X, which is designed to withstand pressures up to 150 MPa and temperatures up to 1,000 °C. The operating conditions are 100 MPa and 600 °C. The 100 mL chamber accommodates 50 mL of fuel—graphene and borophane—using core sockets for precise loading control, as shown in Fig. 3. These specifications strike a balance between safety and performance, providing a foundation for future iterations.

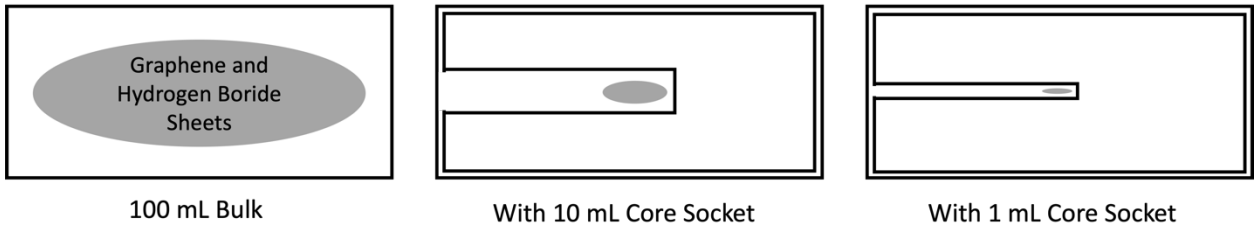

Figure 3. The chamber with core sockets.

4. Experimental Procedures

In the experiment, high-pressure hydrogen gas is generated at temperatures of several hundred °C from the solid graphene-borophane fuel. If hydrogen leaks from the chamber, there is a risk of explosion. The appropriate equipment and safety measures are required to eliminate such risks, following the relevant laws and standards. The possibility of excess heat generation due to nuclear reactions should also be considered. The quantity of this heat has not been theoretically determined yet.

High-pressure gas and residual powder generated during the experiment may contain trace amounts of tritium and the radioactive carbon isotope ^{14}C. In the initial stages of the experiment, the residual amount is expected to be below regulatory limits, but the experiment should be conducted following proper management protocols, including analysis of the waste by mass spectrometry.

Essential safeguards must be incorporated for high-pressure-temperature hydrogen systems, primarily comprising a pressurized explosion-proof enclosure with an inert gas system, a cooling system, and leak detection and monitoring systems, as well as various nuclear detection sensors, as illustrated in Fig. 4.

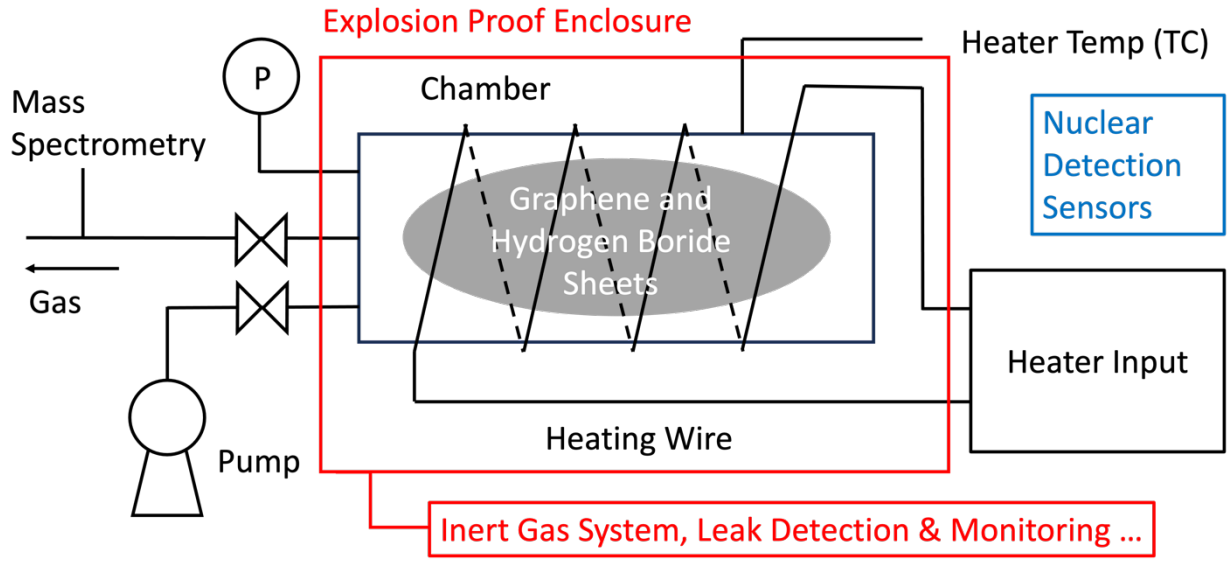

Figure 4. The experimental setup with essential safeguards (shown in red and blue).

The initial experimental procedure involves 5 fundamental steps; however, the safety precautions must also be addressed, as described above.

1. Mix 0.1 g of powdered graphene with 0.02 g of borophane, place the mixture in the 100 mL pressure-resistant chamber (without core sockets), and perform vacuum evacuation.

    - During the initial stages of the experiment, the container performance can be low-spec, gradually increasing in stages.
    - Estimations show that 0.02 g of borophane produces approximately 5 MPa of hydrogen gas in a 100 mL chamber.

2. Heat the chamber's outer wall to 250 °C for 3 h using an electric heating wire wrapped around it.

    - These conditions (250 °C and 3 h) are considered sufficient for hydrogen to desorb from borophane and reach equilibrium.

3. Confirm excess heat on the outer wall.

    - Monitor the temperature using calibrated thermocouples with ±0.1 °C precision, recording data every 10 s to detect excess heat above the baseline electrical input.
    - The Joule–Thomson effect must be accounted for, which describes how the temperature of the gas decreases as its pressure increases.
    - Three control experiments are considered: Control 1, graphene only (0.1 g) under identical conditions; Control 2, borophane only (0.02 g) under identical conditions; and Control 3, Empty container baseline measurement.

4. Stop heating the chamber and let it cool to room temperature.

5. Collect and conduct mass spectrometry analysis on the gas inside the chamber.

    - Mass spectrometry analysis enables the detection of (1) helium isotopes (^{3}He, ^{4}He ^{4}He) as fusion products, (2) tritium (^{3}H) as a potential byproduct, and (3) Carbon isotopes (^{12}C, ^{13}C, ^{14}C) for contamination assessment.

5. Future Work & Optimization

Once the proof-of-concept is demonstrated, the next steps involve optimizing the fusion reaction. This includes determining the optimal mixing ratio of graphene and borophane, as well as refining the powder particle shape and the furnace temperature through experiments and computer simulations. It would also be beneficial to develop fuel rods that can withstand high loads and long-term operation. Ultimately, the fuel rods can be utilized as heat sources in reactors optimized for their output, and complete systems, such as boilers and small module reactors aimed at power generation, can be developed.

6. Concluding Remarks

Despite longstanding skepticism about the viability of cold fusion, recent experimental research has shown significant progress, leading many experts and enthusiasts to question whether this technology can ultimately sustain our modern lifestyle and provide hope for future generations. Hyper-cold fusion, leveraging the unique properties of 2D materials under high pressure, represents a promising pathway to overcome the historical limitations of cold fusion and potentially unlock a new clean energy source.

Acknowledgments

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Appendix A: How Electron Capture Can Occur in Cold Fusion

In this Appendix, one of the controversial theses of cold fusion—electron capture—is explained through the interaction between a plasmon on graphene and hydrogen. A plasmon, a quasi-particle or coherent state of electrons, can move on graphene at a velocity of around 1,000 km/s. When a hydrogen atom enters such a group of electrons, it is easily ionized, becoming a ground-state proton within the plasmon. Electrons in a plasmon are tightly packed but sparsely distributed, as they repel each other due to their negative charge.

Figure 5 shows illustrations before and after electron capture. The upper panel shows the state before electron capture: a plasmon moves toward a proton at 1,000 km/s. When the plasmon collides with the proton, one electron is captured by the proton, forming a neutron. At the moment of capture, the electron's velocity alone is insufficient to form a neutron; without additional factors, the electron would scatter without being captured. However, because electrons in the plasmon are tightly bonded, the scattering energy is rebound by the plasmon, forcing an electron into the proton during electron capture.

The bottom panel shows the state after electron capture: the plasmon loses velocity as its kinetic energy is consumed by the electron capture. This mechanism may enable electron capture at low energies, as in cold fusion.

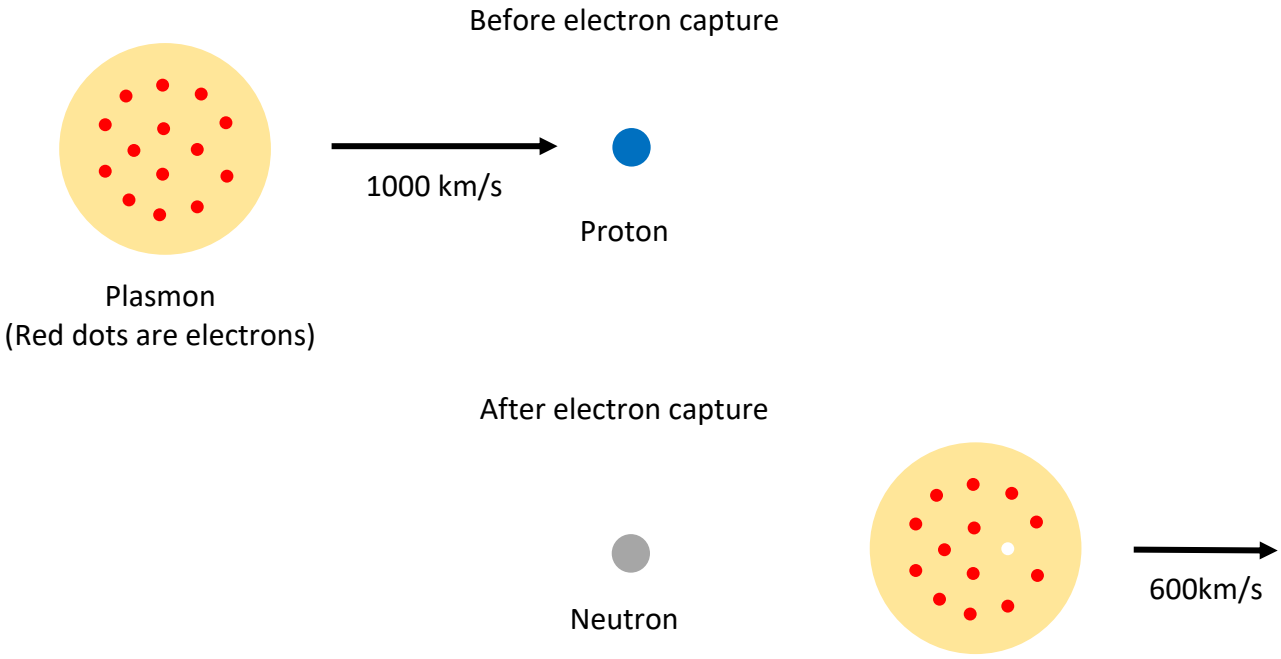

Figure 5. The picture of before and after electron capture.

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