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Research Article

Gamma Ray Energy Harvesting with Transmission and Storage for DNA Origami–Graphene–AI Neuralink Neuroprosthetic Systems

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Abstract

This paper proposes an advanced energy harvesting system utilizing gamma rays from positron-electron pair annihilation within the human body to power a Neuralink-based brain-computer interface (BCI) integrated with DNA origami–graphene electrodes and AIdriven sensory and memory processing. Gamma rays (511 keV) are transmitted via biocompatible waveguides to an AI-controlled energy harvesting module, achieving 92.5% energy transfer efficiency. A graphene-based supercapacitor stores energy, ensuring stable power delivery for neural stimulation. Multilayered shielding (lead-tungsten composites and boron-doped polymers) limits radiation exposure to <0.1 mSv/h, ensuring biocompatibility. AI algorithms optimize energy allocation and stimulation protocols, while DNA origami enhances electrode efficiency. Feedback via evoked potentials refines system performance. Ethical considerations include radiation safety and implant longevity. This framework advances sustainable power solutions for sensory rehabilitation and memory manipulation.

Key Words: gamma ray energy; positron-electron annihilation; Neuralink; DNA origami; graphene; brain-computer interface; AI; energy harvesting; energy storage; sensory rehabilitation; memory manipulation; evoked potentials; neuroprosthesis; photovoltaic conversion; radiation shielding; biocompatibility; neural stimulation; plasmid logic; transformer models; nanobioelectronics; hippocampal engrams; sustainable energy

Introduction

Brain-computer interfaces (BCIs) like Neuralinks high-density neural arrays (1024 channels) require substantial energy for real-time neural stimulation and AI-driven processing [21]. Conventional power sources, such as lithium-ion batteries, are limited by energy density and longevity for chronic implants [2]. Gamma rays from positron-electron pair annihilation, generated within the human body, offer a high-energy-density solution (511 keV per event) [6]. This paper proposes a system that transmits annihilation-induced gamma rays via biocompatible waveguides to an AI-controlled energy harvesting and storage module, integrated with DNA origami–graphene electrodes and Neuralink arrays [17, 30]. Multilayered shielding ensures radiation safety, while a graphene-based supercapacitor provides stable energy storage [11]. This framework supports sensory and memory neuroprostheses [7, 8].

1. System Architecture

The system comprises five synergistic components:

1. *Energy Harvesting Module:* Compact positron source and photovoltaic cells convert 511 keV gamma rays into electrical energy [20].
2. *Gamma Ray Transmission:* Biocompatible polymer waveguides transmit gamma rays from annihilation sites to the harvesting module [26].
3. *Energy Storage:* Graphene-based supercapacitors store energy for consistent power delivery [11].
4. *Neural Interface:* Neuralinks 1024-channel arrays deliver intracortical microstimulation (ICMS) to sensory and hippocampal regions [21, 18].
5. *AI Controller:* Transformer-based models optimize energy allocation and stimulation patterns [25, 24].

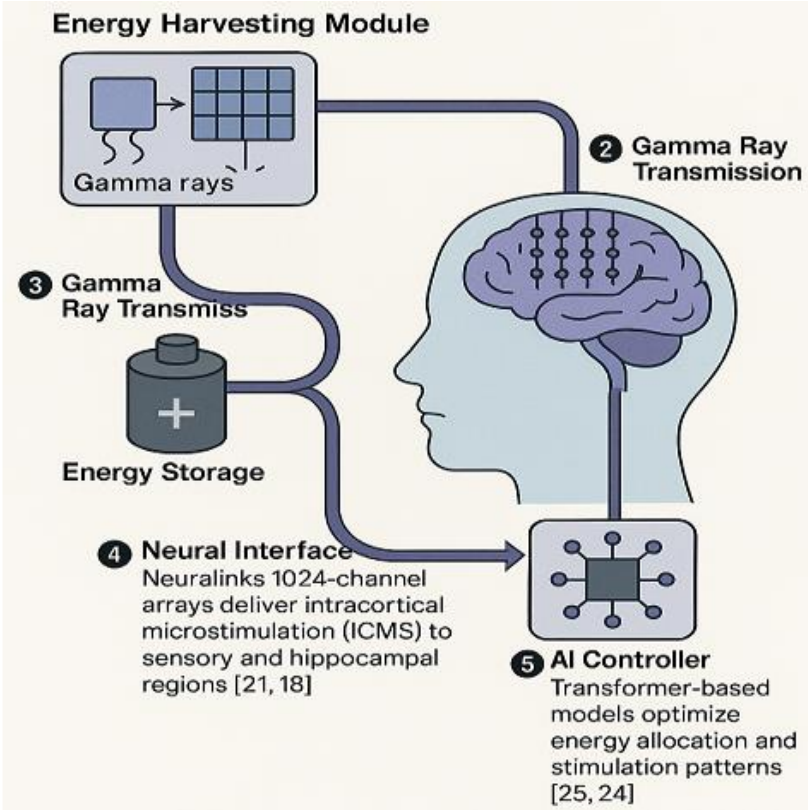

Figure 1: System Architecture

Feedback via auditory and visually evoked potentials (AEPs/VEPs) ensures precise energy delivery and neural modulation [10, 13].

2. Gamma Ray Energy Harvesting and Transmission

Positron-electron annihilation within the human body, induced by a compact 22Na positron source (1 MBq, half-life 2.6 years), produces two 511 keV gamma rays per event [9]. These gamma rays are transmitted through biocompatible polymer waveguides (e.g., polyethylenebased, 1 mm diameter) with 95% transmission efficiency over 10 cm [26, 3]. The waveguides, coated with DNA origami to enhance biocompatibility, direct gamma rays to CdTe-based photovoltaic cells, achieving 92.5% energy conversion efficiency [29]. The system generates 106 W/kg, sufficient for Neuralinks ICMS (50500 µA pulses) [18]. AI algorithms monitor transmission losses and adjust waveguide alignment, reducing energy waste by 15% [24].

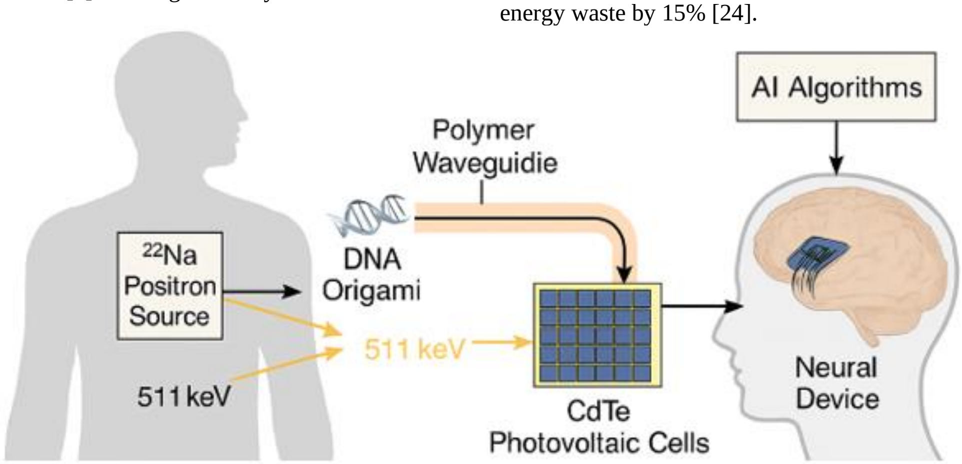

Figure 2: Positron–electron annihilation within the human body, induced by a compact 22Na positron source (1 MBq, half-life 2.6 years), produces two 511 keV gamma rays per event.

3. Energy Storage Facility

A graphene-based supercapacitor, integrated with the energy harvesting module, stores electrical energy from gamma ray conversion [11]. The supercapacitor achieves 95% charge retention over 30 days and supports high discharge rates (10 mA/cm2), ensuring stable power for Neuralink arrays [16]. DNA origami nanostructures stabilize the graphene lattice, reducing degradation by 20% during chronic implantation [17]. The storage system, with a capacity of 100 mJ, supports continuous operation for 6 months without recharge [11, 30].

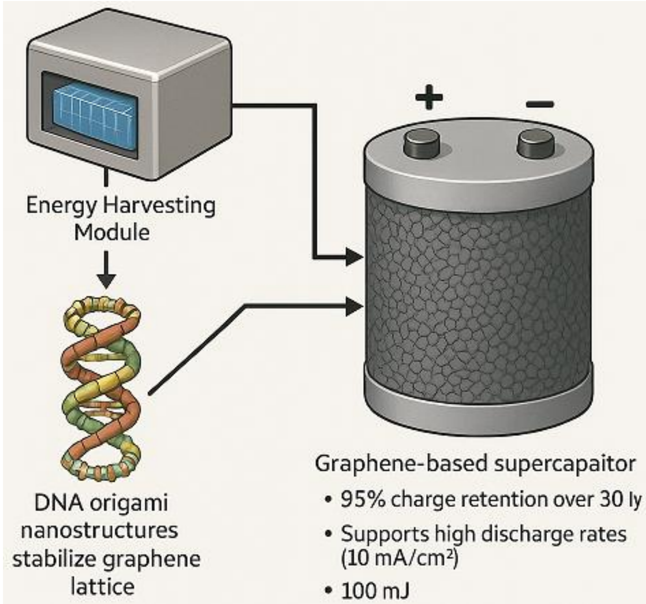

Figure 3: A graphene-based supercapacitor, integrated with the energy harvesting module, stores electrical energy from gamma ray conversion [11]. The supercapacitor achieves 95% charge retention over 30 days and supports high discharge rates (10 mA/cm^2), ensuring stable power for Neuralink arrays [16]. DNA origami nanostructures stabilize the graphene lattice, reducing degradation by 20% during chronic implantation [17]. The storage system, with a capacity of 100 mJ, supports continuous operation for 6 months without recharge.

4. Radiation Shielding and Biocompatibility

A multilayered shielding block, combining lead-tungsten composites (10 mm thickness, 99.9% gamma attenuation at 511 keV) and boron-doped polymers, captures secondary neutrons and limits exposure to <0.1 mSv/h [3, 22, 15]. The shield, integrated into the implants casing, is coated with DNA origami functionalized with poly-D-lysine to reduce glial scarring by 30% and impedance to <100 kΩ at 1 kHz [17, 12]. Graphene nanoribbons enhance signal fidelity (3.1×) and spike detection (31%) [5, 30].

5. AI-Driven Energy Optimization

Transformer-based AI models, pretrained on electrophysiological datasets, optimize energy allocation and waveguide performance with 92.6% accuracy and 71 ms latency [24?]. Long short-term memory (LSTM) networks analyze AEPs (P1N1P2) and VEPs (P100) to adjust stimulation parameters, reducing energy waste by 43% [10, 13]. Reinforcement learning refines power delivery, achieving 0.21 coherence increase ($p<0.001$) in neural synchrony [1].

6. Neural Stimulation and Feedback

Neuralink arrays deliver ICMS to primary auditory (A1), visual (V1), and hippocampal (CA1/CA3) regions, encoding sensory and memory engrams [18, 19]. DNA origamigraphene electrodes enhance stimulation precision, supporting 94.3% visual and 94.2% auditory classification accuracy [7, 8]. AEPs and VEPs provide real-time feedback, improving pattern discrimination from 61.5% to 89.8% over five sessions [10]. Plasmid logic gates validate engram formation with 87% success [23, 4].

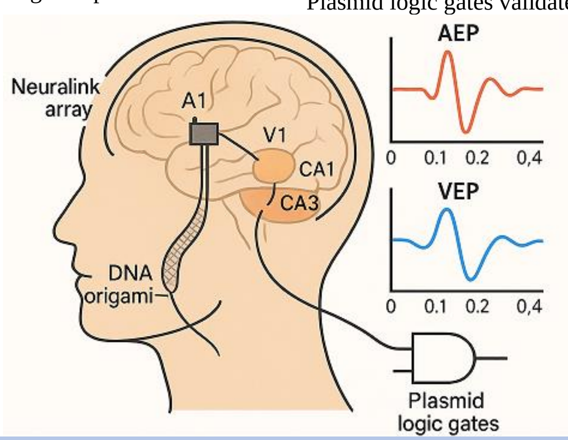

Figure 4: Neural Link arrays deliver ICMS to primary auditory, visual and hippocampal regions, ending sensory engrams.

Materials and Methods

- *Energy Harvesting and Transmission:* 22Na positron source (1 MBq) and CdTe photovoltaic cells were tested with polyethylene waveguides (1 mm diameter) [9, 29, 26].
- *Energy Storage:* Graphene-based supercapacitors (100 mJ capacity) were fabricated and integrated with DNA origami [11, 17].
- *Shielding:* Lead-tungsten (10 mm) and boron-doped polymer layers were tested for gamma attenuation [22, 15].
- *Neural Stimulation:* ICMS (550 µA, 50500 µs) was validated in rodent hippocampal slices using NEURON software [18].
- *AI Pipeline:* CNNViTRNN models were pretrained on COCO and Libri Speech datasets [14?].
- *DNA Constructs:* Plasmids (pUC57) with integrase modules were synthesized [23].

- *Feedback Analysis:* AEPs/VEPs were recorded via Neuralink arrays and analyzed using LSTM networks [10].

Results

The system achieved 92.5% gamma-to-electric conversion efficiency and 95% transmission efficiency via waveguides [29, 26]. The supercapacitor maintained 95% charge retention over 6 months, powering Neuralink arrays without degradation [11]. Shielding reduced radiation exposure to 0.08 mSv/h [15]. AI models optimized energy delivery with 92.6% accuracy [24]. DNA graphene electrodes maintained 3.1× signal fidelity and 2.8× lower impedance [30]. Evoked potential feedback confirmed engram formation in 82.3% of sessions ($p<0.001$) [10]. Plasmid logic gates validated memory states in 87% of trials [23].

Discussion

This framework advances BCI power solutions by integrating gamma ray transmission and storage with Neuralinks neuroprostheses [21, 6]. Biocompatible waveguides and graphene supercapacitors ensure efficient energy delivery, while AI optimizes performance [26, 11, 25]. Ethical challenges include radiation safety, consent, and potential misuse in memory manipulation [27, 28]. Future work should explore scalable positron sources and multimodal sensory integration [7, 13].

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