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Neutron Voltaic: Converting Neutrons' Energy Directly to Electricity

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The fundamental energy transformation that occurs in a nuclear power plant involves converting the kinetic energy of fission process fragments into thermal energy. The reactor coolant is maintained at temperatures typically between 300-400℃, which limits the efficiency of energy conversion from thermal to mechanical and then to electrical to around 30-35%. The average energy of neutrons produced during fission is approximately 2.0 MeV or 1.55×10^10 K. However, these high-energy neutrons eventually slow down, resulting in a loss of their energy quality, until they reach a much lower energy level of 50 meV or 600K.

It is possible to convert the energy of neutrons during the moderation process into electrical energy by incorporating carbon nuclei into a p-i-n diamond Schottky diode. This technology works similarly to betavoltaic devices that produce electrical energy by collecting electron-hole pairs generated from the energy of beta particles released during radioactive decay. However, the high radiation levels present in a nuclear reactor can overcome the inefficiencies associated with the thin layers' geometry of betavoltaic devices. Moreover, diamond material exhibits remarkable radiation, thermal, and chemical tolerance, making it an ideal candidate for use within intense radiation fields of the nuclear reactor.

A Schottky diode is proposed to be formed using diamond as the interaction material and graphite as the conductor. Beryllium and oxygen, which have low neutron absorption cross sections, will be used as doping elements. The device will serve both as a direct energy conversion device and a neutron moderator. The concept is to be explored in terms of known nuclear radiation flux characteristics and performance of diamond as a radiation detector material in different radiation sources contexts.

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