EVIDENCE OF HEAVY-ION REACTIONS FROM INTENSE PULSED WARM, DENSE PLASMAS*

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Nuclear reactions in pulsed-power ion-diodes are usually induced by proton- or deuteron-projectiles accelerated to high energy by the voltage across the anode-cathode (A-K) gap. Reactions for which the incident projectile has a larger atomic number ($Z > 2$) are inhibited by the Coulomb barrier and are not usually detected. This work documents the detection of several heavy-ion nuclear reactions in the operation of a plasma-filled rod-pinch (PFRP) diode fielded on the 2-MV Gamble II generator[1] in which the required Q-value is larger than the A-K potential difference. By injecting a cable-gun plasma between an anode-cathode gap, this PFRP diode has been shown to concentrate a 500-kA, 2-MeV, 60-ns electron beam onto the pointed end of a 1-mm diameter tapered tungsten rod, generating a warm-dense tungsten plasma (up to W^{+12}, ~20 g/cm^3, 25 eV, and 2.4 MJ/cm^3). To utilize the PFRP diode as a source of highly-charged ions, high-intensity electron beams impinge upon a ~1-mm diameter Al anode rod charged to high-voltage. After an experimental discharge, anode material debris is collected in a 3-in diameter Al cup (at ground potential) and gamma-ray emissions are measured using a high-purity Ge spectroscopy system over several days. By measuring the gamma-ray energies and half-lives, the production of a variety of radioisotopes were identified, including ^{38}K, ^{34m}Cl, ^{43}Sc, ^{44m}Sc, ^{48}V, and ^{52}Mn (up to 10^8 per discharge). Weak evidence for ^{24}Na, ^{69}Ge, and ^{79}As was also observed. Heavy-ion nuclear reactions with Q-values exceeding the accelerating potential of the diode are proposed to explain the presence of several observed radioisotopes, suggesting a novel acceleration mechanism. Although the production of these isotopes in sub-10-MeV accelerators has been observed before[2,3], this is the first demonstration of their production using a PFRP diode.

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2. R.A. Meger, et al., "High Impedance Ion-Diode Experiment on the Aurora Pulser," J. Appl. Phys. **52**, 6084 (1981).

3. P. McKenna, et al., "Demonstration of Fusion-Evaporation and Direct-Interaction Nuclear Reactions using High-Intensity Laser-Plasma-Accelerated Ion Beams," Phys. Rev. Lett. **91,** 075006, (2003).

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