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Development of ¹²C-enriched irradiation-resistant diamond targets for astrophysical ¹²C(α, γ)¹⁶O reaction measurements

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The ¹²C(α, γ)¹⁶O reaction plays a pivotal role in nuclear astrophysics research. The direct measurement of this reaction remains particularly challenging due to its extremely low cross section (approximately 10⁻¹⁷ barn at 300 keV) within the Gamow window. This study addresses the critical need for irradiation-resistant ¹²C-enriched targets to enable accurate measurements. We successfully fabricated a ¹²C-enriched diamond target on molybdenum substrate through Microwave Plasma Chemical Vapor Deposition (MPCVD), demonstrating remarkable stability under high-intensity proton beam irradiation. Experimental results revealed only a 1.8% decrease in the ¹²C(p, γ)¹³N reaction yield in the ¹²C layer following proton bombardment at 270 keV with 2 mA beam current and a total accumulated charge of 124.2 C, indicating a significant improvement compared to conventional carbon targets. Isotopic analysis confirmed a ¹³C/¹²C ratio of (9.7 ± 1.3) × 10⁻⁵, verifying the absence of contamination during MPCVD processing. Additionally, we developed a novel nuclear-reactionbased methodology for quantifying hydrogen content in thin films, establishing an upper limit of 0.058% (95% confidence level) for hydrogen concentration in the diamond target. The combined irradiation resistance and isotopic purity of this target meet the stringent requirements for direct ¹²C(α, γ)¹⁶O reaction measurements in astrophysical environments.

Research field of your presentation

Experimental Low-energy nuclear physics

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