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Tailor-made materials for radioactive ion beam production

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At CERN-ISOLDE, over a thousand radioactive ion beams (RIBs) are produced from over 70 different types of target materials through the isotope separation online method (ISOL). The material is hit with a 1.4 GeV proton beam and undergoes nuclear reactions leading to the production and extraction of artificially created isotopes which are then ionized and extracted as ion beams.[1]
The design of target materials must therefore balance the need for high cross-sections and high numbers of target nuclei for maximum in-target isotope production versus fast and efficient diffusion and effusion processes. This requires a compromise between density and pore structure, while keeping the required levels of thermal stability to limit sintering and maintain these properties in online operational conditions (which can reach over 2200o C). Additional considerations include power deposition from the incident proton beam, and chemical interactions that can volatilize or bind isotopes of interest, the choice of suitable nuclear reaction pathways to create the desired isotopes, and mechanical, thermal and vacuum conditions required for operation of associated infrastructure such as the ion source.
Recent efforts were made to develop more specialized target materials with microstructure tailored to the application and to test production yields during operation online at ISOLDE to determine their suitability for RIB production, focusing on the production short-lived isotopes and refractory species requiring high temperature target materials.
To fully understand such materials the microstructural stability of the material and the produced RIB yields under different operating conditions were assessed through offline and online studies, and the focus was put on ceramic materials which have proved particularly challenging to employ in the past such as zirconia as it tends to fully sinter when heated inside an ISOLDE target[2] and refractory carbides such as tantalum carbide, a novel type of ISOL material.
First results obtained this year at ISOLDE will be presented demonstrating improvement on existing materials by tailoring the material's structural characteristics to the requested radioisotope beam, providing fast release of isotopes and presenting good stability under online operating conditions even for traditionally difficult lanthanide beams. Future development plans for ISOL target materials will also be discussed.

Keywords: radioisotopes, refractory materials, tantalum carbide, ion beams, lanthanides

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