Actinide target materials for the production of radioactive ion beams at CERN-ISOLDE

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Abstract

The Isotope Separation OnLine (ISOL) is a technique used to produce relatively pure radioactive ion beams of several elements, with half-lives down to a few milliseconds. This is done by impinging highly energetic particles, usually protons, into a target promoting nuclear reactions of spallation, fragmentation, fission and fusion. The thermalized radionuclides have then to escape from the bulk of the target, which is usually kept at temperatures close to 2000 °C to promote diffusion of the isotopes and respective evaporation until they reach an ion source where they are ionized. After being ionized the isotope ions are accelerated up to 60 keV to be mass separated according to their mass over charge ratio using the Lorentzian principle, and delivered for physics experiments. This technique is used in facilities such ISOLDE at CERN (Switzerland), ISAC in TRIUMF (Canada) and in the future PTF (Proton Target Facility) integrated within the MYRRHA Phase 1 project (MINERVA), here at SCK•CEN.

In the case of ISOLDE at CERN (the current leading ISOL facility) more than 1000 different isotope beams of 74 chemical elements, with half-lives down to few milliseconds, are produced impinging 1.4 GeV protons on a thick target (2 cm diameter, 20 cm length). The produced beams are mainly used in fundamental but also applied research in fields such as nuclear, atomic, solid state, astro-, bio- and medical physics. The targets of ISOLDE have more than 50 years of development invested into, where about 30 different target materials are used. These materials are usually molten metals and refractory metals, oxides or carbides in powder or pellet forms.

Almost 50% of the targets used at ISOLDE are made of actinide carbides with excess graphite, where the great majority is made of uranium carbide but also a few targets made of thorium carbide. The uranium and thorium carbides are synthetized in-house from the carbothermal reduction of their respective oxides. They are first mixed with excess high purity excess graphite, pressed into thin pellet and heated up in vacuum to 2000°C to promote the carbothermal reduction.

In this talk, an overview of the ISOLDE facility will be given with focus on actinide carbides material production and as well development towards microstructure engineering for more efficient release of isotopes.