

Characterization of the MAFF Fission Target \diamond

A. Kohlhund, P.G. Thirolf, D. Habs, H.J. Maier, H.U. Friebel, F. Nebel, R. Stoepler, W. Carli, M. Groß, and J.B. Neumayr

Highly intense beams of radioactive fission fragments can be obtained exploiting the large cross section for thermal neutron induced fission of uranium. Not only within the MAFF project at the FRM 2 in Garching, but also for other next-generation radioactive ion beam facilities n-induced fission is envisaged as production mechanism for intense neutron-rich nuclear species. While for MAFF 10^{14} fission events/second are envisaged using a compact source (ca. 1 g ^{235}U homogeneously dispersed in a porous graphite matrix), the planned EURISOL facility aims at a fission rate of 10^{15} fiss/s using massive ^{238}U fission targets. Being confronted with several technical challenges around the manufacturing and operation of the fission source, prototype tests and characterization experiments have been performed at the MLL.

A prototype of the in-pile ion source for MAFF was built from high-melting materials, since the ion source will be operated at a temperature of about 2400°C due to the nuclear heating by the fission process. In order to compensate for the nuclear burn-up of the ^{235}U fuel during the 52 days reactor cycle at the FRM 2, the target will be externally heated with a tungsten filament by electron bombardment. The Re target cylinder containing the graphite matrix is surrounded by several heat shields are supposed to confine the high temperature in the center of the source [2].

Operating the fission source at such high temperatures is on the one hand favorable in view of a fast diffusion/effusion ion extraction, permitting short-lived ion beams to be produced with reasonable yield. However, the technical realization has to prove high-temperature durability, especially in view of the ceramic insulators that have to withstand the extraction voltage of 30 kV under extreme thermal conditions. Therefore a test program was set up in order to allow for high-temperature tests of the ion source. For this purpose, a high-temperature vacuum furnace has been set up, which is capable to provide the operational temperature of up to 2400°C at vacuum pressures between 10^{-5} and 10^{-6} mbar even for long-term tests. Details of the furnace design are given in [1]. In order to reach the design specification of 2400°C , modifications had to be introduced, mainly improving the cooling concept and extending the safety interlock precautions.

During the commissioning measurements, all design specifications could be met, the furnace was heated without problems up to 2600°C . A long-term test for 50 hours at $T=2300^\circ\text{C}$ could also be performed. A central question that had to be clarified concerns the sublimation properties of the graphite matrix enclosed by a cylindrical target container. While for the MAFF target a Re container is foreseen, for the first test the porous graphite cylinder was enclosed in a Ta container. This first test at around 2300°C indicated a rather large carbon sublimation rate, consequently systematic studies were performed to quantify the temperature dependence of the sublimation curve. For simplicity these measurements were performed with

bare cylindrical graphite samples of 6.5 g. The results are shown in Fig. 1, where the strong rise of the sublimation rate above 2000°C is visible. The experimental results are compared to values known from literature, indicating a significantly increased sublimation for the porous graphite used in the MAFF fission source, which recommends a lowering of the operational temperature of the fission source to about 2000°C in order to allow for the envisaged long-term operation of up to 52 days.

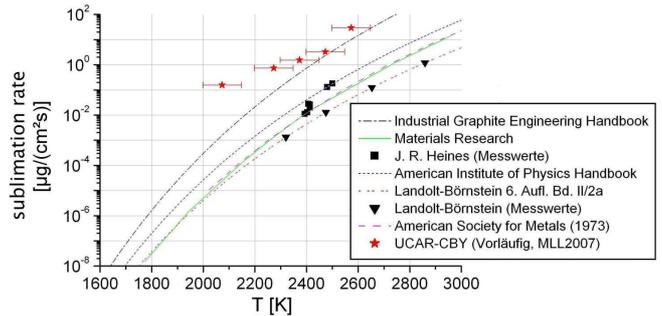


Fig. 1: Temperature dependence of the carbon sublimation rate at a residual pressure of $1\text{-}4\cdot 10^{-4}$ mbar.

In order to study the beam extraction properties of the target/ion source the beam emittance from stable ions extracted from the MAFF prototype was characterized in the ion source laboratory of the MLL. Instead of uranium the graphite matrix was loaded with Nd, enabling to extract a the series of stable isotopes. A filament heated the target to a temperature of 2100°C . The normalized emittance was measured with an emittance meter [3], where the ion beam enters and in a first stage a parallel shift of the beam is induced in order to determine the position x . By inducing an angular deflection in the second part, the angular divergence x' is obtained. Scanning for all values of x , x' , y and y' and detecting the beam current in a Faraday cup it is possible to calculate the normalized transverse beam emittance (see Fig. 2). A value of $\epsilon = 12.5\pi$ mm mrad could be derived at an extraction potential of 30 keV. This value is in excellent agreement with expectations from ion optical calculations.

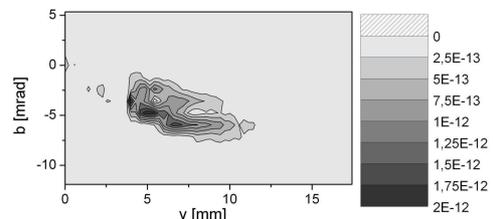


Fig. 2: Beam emittance ellipse measured for the MAFF fission source prototype at an extraction potential of 30 keV.

References

- [1] H.J. Maier *et al.*, Nucl. Instr. Meth. **A438** (1999) 185
- [2] D. Habs *et al.*, Annual report 2004, p. 75
- [3] A. Wilfart, diploma thesis, 2002

\diamond Supported by the European Commission within FP6 through I3-EURONS under contract no RII3-CT-2004-506065