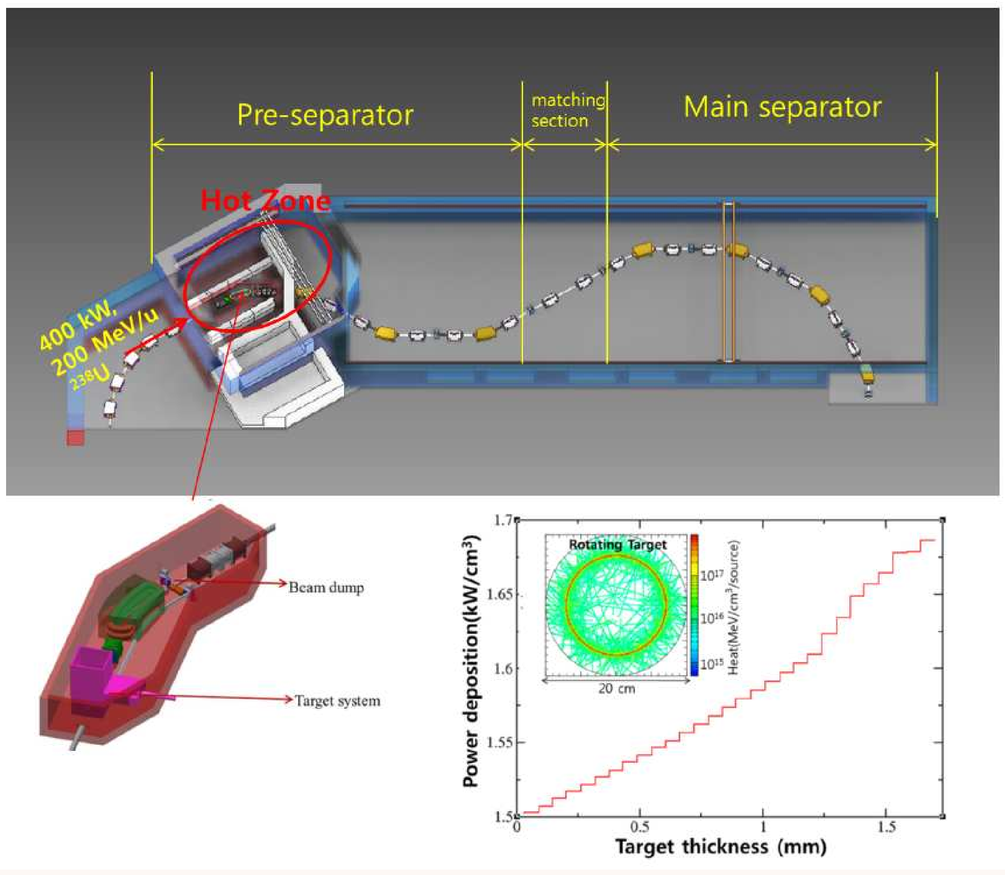
Design and test of a graphite target system for in-flight fragment separator

J.W. Kim, S.G. Hong, J.S. Song, J.H. Kim
Rare Isotope Science Project (RISP), Institute for Basic Science (IBS)
Daejeon, South Korea
jwkim@ibs.re.kr

Abstract

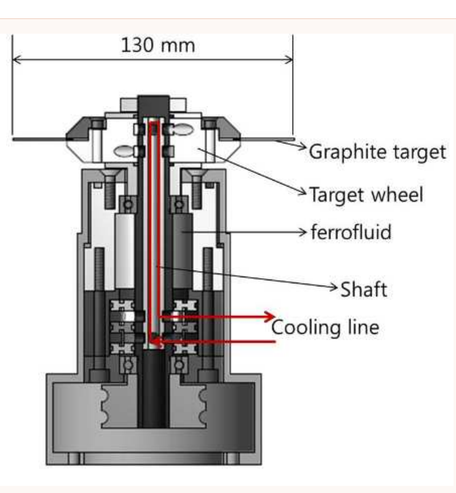
A graphite target system to produce rare isotope beams using in-flight fragmentation method has been designed for the rare isotope science project in Korea. A main primary beam to bombard the target is 238U in the energy of 200 MeV/u with the maximum power of 400 kW, in which beam power deposit on the target amounts up to 100 kW. A multi-slice target concept was adopted to enhance the radiation cooling effect. A finite element program ANSYS was used to analyze thermo-mechanical behavior of single and multi-slice targets. To validate the design, electron beam at the energy of 50 keV was used to test a single slice target. A good agreement of hot spot temperature was achieved between simulation and measurement. Results of simulation and electron beam simulations will be presented along with a plan to test multi-slice targets.

Introduction



- Concept of graphite target was chosen for the baseline design as a production target for the in-flight fragmentation
- An optimized thickness of the graphite target is around 1.73mm for the energy of 200MeV/u to produce ^{132}Sn,which is a representive isotope produced by IFF method
- Beam energy deposit on graphte target is estimated by PHITS calculation for a graphite target of 1.73 mm thick
- Need to separate the target vacuum area to allow for the exchange of the target system every two weeks in average

Single-slice target system

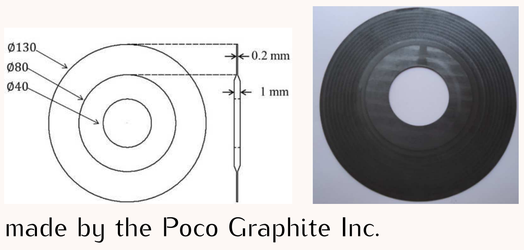


Rotating single-slice target system

- test conditions

kin. E	50keV	power	500W
spot size	$\sim$ 1mm	penetration depth	0.04mm
diameter	13cm	thickness	0.2mm

- Target diameter was chosen to be 13cm which was limited by vacuum chamber diameter of electron linear accelerator
- Both uniform and tapered graphite disk was tested
- Air and water cooling system was considered to avoid increasing the temperature of other components

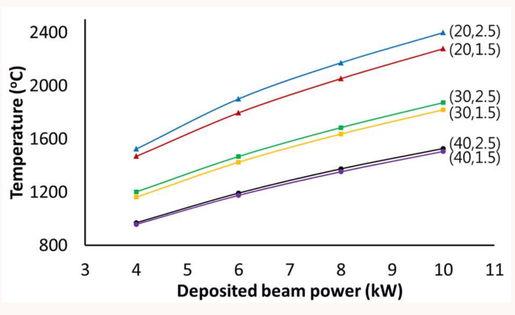


made by the Poco Graphite Inc.

- Physical properties of graphite
- Density : 1.5 $\sim$ 1.8g/cm^3
- Elasticity
  - Young's modulus: 9.2 GPa
  - Poisson's ratio: 0.31
  - Bulk modulus: 8 GPa
  - Shear modulus: 3.5 GPa

ANSYS simulation for single- and multi-slice target

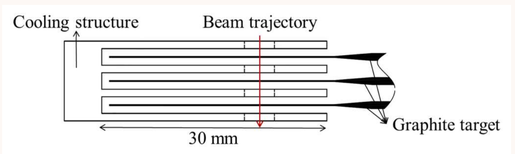
For the single-slice target



power deposit per slice	temperature[^{0}C] 30cm	40cm
4kW	1160	960
6kW	1420	1180
8kW	1640	1350
10kW	1820	1510

- Peak temperatures for two different target diameters

For the multi-slice target

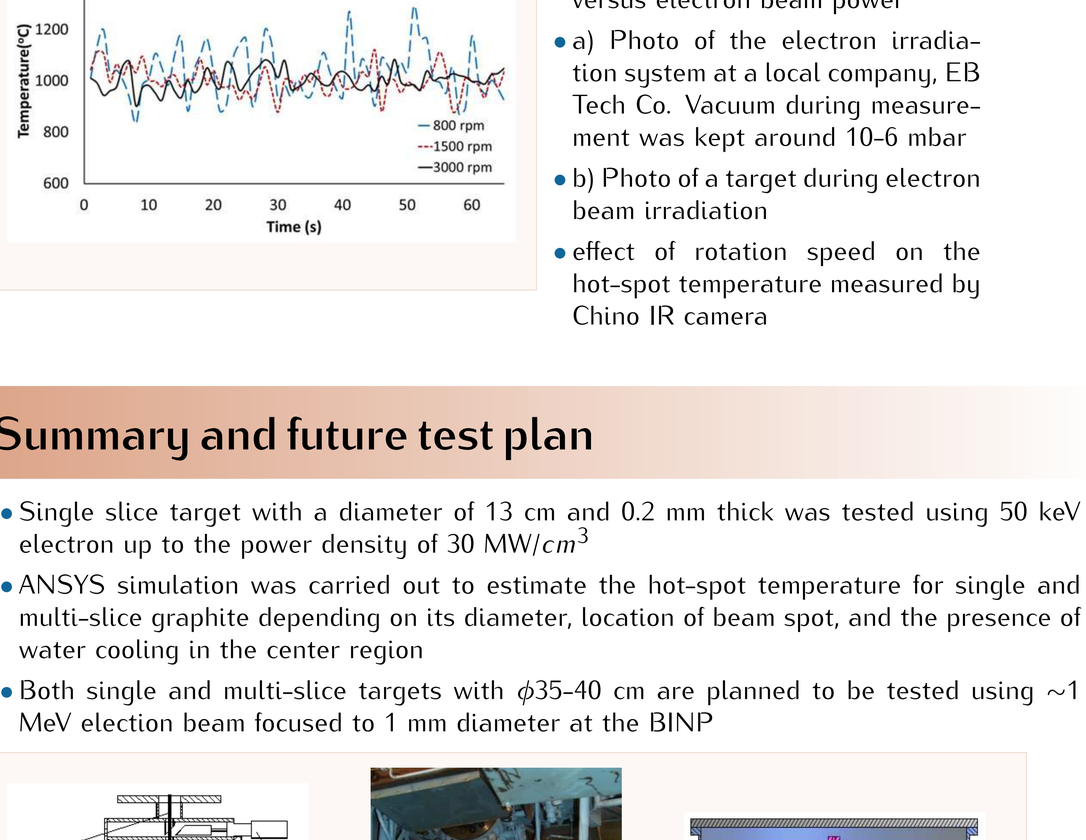


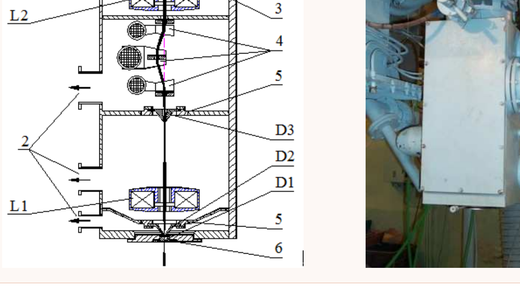
confguration of a multi-slice target used for ANSYS simulation

power deposit per slice	temperature[^{0}C] middle slice	outer slice
4kW	1450	1240
6kW	1780	1520
8kW	2020	1730
10kW	2250	1920

- Hot spot temperatures on three slices with a diameter of 30cm

Temperature measurements on the beam spot





- comparison of measured temperatures to ANSYS simulation results versus electron beam power
- a) Photo of the electron irradiation system at a local company, EB Tech Co. Vacuum during measurement was kept around 10-6 mbar
- b) Photo of a target during electron beam irradiation
- effect of rotation speed on the hot-spot temperature measured by Chino IR camera

Summary and future test plan

- Single slice target with a diameter of 13 cm and 0.2 mm thick was tested using 50 keV electron up to the power density of 30 MW/cm^3
- ANSYS simulation was carried out to estimate the hot-spot temperature for single and multi-slice graphite depending on its diameter, location of beam spot, and the presence of water cooling in the center region
- Both single and multi-slice targets with ϕ35-40 cm are planned to be tested using $\sim$1 MeV election beam focused to 1 mm diameter at the BINP