Analyses and the effect of impurities contained in charge stripper foils for the 3-GeV RCS of J-PARC

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Abstract

A charge stripper foil is one of key technology to keep high operating rate for multi-turn injection of high power proton synchrotron. Typically carbon-based material is used to strip two electrons off the incident H^- beams. J-PARC also requires carbon stripper foils to strip electrons from H^- supplied by the linac in order to inject H^+ into the Rapid Cycling Synchrotron (RCS). It is important for a charge stripper foil to endure heat load by energy deposition from the beam. For a charge stripper foil in the RCS, we applied the Hybrid type thick Boron-doped Carbon (HBC : Boron 20%) foil which is developed with the arc-discharge method by Sugai and has toughness for standing against high beam irradiation. For the beam operation in RCS, the foil thickness is about 1μm (200μg/cm^2) corresponding to conversion efficiency of 99.7% for 181MeV injection from linac.

We have investigated to develop much more long-lifetime foil about for five years with TEM, Ion-irradiating machine, RBS, PIXE and so on in Tokai and TIARA (Takasaki Ion Accelerators for Advanced Radiation Application). In the research, we found that impurities content such as Fe, Cu, Na, Al differed from each foil. HBC had generally amorphous phase, but they involved a lot of micro graphite grains of a few nanometer and many boron-rich micro grains before irradiation of ions. In impurities, we observed that metals such as Fe and Cu encouraged to crystallize micro grains from disorder atoms. This phenomenon is one of the destructive mechanisms of the HBC foil. Such metals also contribute a large-angle scattering and neutrons' generation by nuclear reaction against the injecting beam, as a result residual radioactivity was increased around the foil.

On the other hand, though we actually have never exchanged a HBC foil for the reason of distraction by the beam operation, we have a big problem with residual radioactivity of foil itself and components around it. By energy upgrade of linac from 181MeV to 400MeV, the problem get more serious to increase residual radioactive dose. By nuclear reaction with the proton beam, long half-life radioactive isotopes such as Na-22 and Be-7 mainly were detected from the irradiated foils. Be-7 is generated from Boron including as the basic in HBC. Na-22 is generated from impurities such as Na and Al contained in charge stripper foils. Especially Na-22 has year-order long half-life and workers must be exposed to radiation while treating the irradiated foils.

We will report about improvement of production control not to contain impurities into foils in various ways, and also point out issues that we should resolve in the near future.