Advanced cladding technologies for beam absorbers and secondary particle producing targets

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The development of advanced beam intercepting devices (BIDs) for the next generation high-energy physics experiments for both the Energy and Intensity Frontier [1] will involve having to cope with increased dissipated average power and energy density. This is coupled with additional constraints, which include ultra-high vacuum (UHV), reliability, radiation damage and radiation protection aspects.

In this framework, at the European Laboratory for Particle Physics (CERN), we have expanded the use of diffusion bonding assisted by Hot Isostatic Pressing (HIP) at CERN for beam intercepting devices systems, and applied for the LHC Injector Upgrade (LIU) Project [2] as well as for the Physics Beyond Colliders initiative [3]. Bonding dissimilar material with the HIP methods allows to maximize the heat transfer coefficient between the different materials and therefore increase the capabilities to cope with power dissipation.

Cuprous materials (such as Cu-OFE, CuCr1Zr and ODS alloys such as Glidcop or Discup) have been bonded via HIP with stainless steel. The technology was already developed for fusion reactors [4] but at CERN we have further expanded the technique for very large components (up to 2.5 meters), required for the fabrication of the LIU-SPS internal beam dump (so called TIDVG5 [5]), which will be operational during 2021. The technology has a large potential for dumps and absorbers for a variety of different facilities, not only for proton driven, but also for electron or photon driven (synchrotron light) facilities, where the dissipated power requirements could be exceeding 100 kW.

Refractory metals are also widely employed in laboratories worldwide for secondary beam production, such as for neutron production [6] or for proposed beam dump experiments [7], owing to their reduced nuclear interaction length and relatively low neutron inelastic cross-section. Nevertheless, directly cooling with water is not possible due to the relatively high hydrogen embrittlement. Usually tungsten is cladded via HIP with pure Ta, with good results [8]. For the proposed CERN's Beam Dump Facility Project [9], we have developed advanced techniques to clad pure W as well as Mo-alloys (such as TZM) with pure Ta as well as – for the first time – Ta2.5W [10] [11]. Beam irradiation of prototype target have been successfully executed during 2018 [12] with post irradiation examination (PIE) to be further expanded during 2021. For high power facilities, decay heat on Ta and Ta-alloys may pose safety concerns: for this reason, within the framework of BDF, other cladding materials shall be studies, including zircalloy or other Nb-alloys, which still possess excellent corrosion resistance capabilities. These R&D techniques will be beneficial for future Hidden Sector experiments [7] as well as for other neutron production facilities, such as the ORNL SNS Second Target Station project [13].

These R&D techniques shall be complemented with instrumented in-beam tests [12], both at fast and slow extraction facilities, as well as with post irradiation examination (PIE) techniques, in order to validate the simulation packages and ensure the bonding quality (mechanical and thermal) after irradiation.

In conclusion, it is suggested that advanced cladding technologies will be fundamental for the development of reliable and robust beam intercepting devices for the future Intensity and Energy Frontier facilities.

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