Good results obtained with a novel technology to produce large-scale neutron converters

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A European collaboration is developing an atmospheric plasma deposition system to produce Boron-10 layers to cope with the Hellium-3 shortage.

Helium-3 is widely used in neutron detectors worldwide. However, due to a 3He shortage that caused its price to rise, it is necessary to find affordable alternatives for neutron detectors. A team of the detector laboratory at the Helmholtz-Zentrum Berlin (HZB) is exploring new techniques for the production of boron-10 (10B) layers. This work is part of a Joint Research Activity on Detectors supported by NMI3. In the video, Thomas Wilpert, Andriy Styervoyedov, and Svyatoslav Alimov from HZB explain a new promising technology.

The best techniques to produce 10B layers

The standard technique to produce 10B layers is magnetron sputtering, which is a vacuum-based technology that needs days of work to create one m^2 of neutron converter. An instrument for inelastic neutron scattering has a large detection area of 10 to 100 m2 and requires a stack of 20 to 30 10B-based layers of about 1 μm thickness to achieve satisfying detection efficiencies. Thus, in total 200-3000 m^2 10B-layers have to be produced per instrument in reasonable time at affordable prices.

After exploring a number of alternative techniques suited to coat delicate aluminium substrates, the HZB team found a good candidate that could do the job: an atmospheric pressure plasma is able to produce needed converters much faster and uses the precious source material more efficiently.

Atmospheric plasma is rapidly developing direction in thin films coatings technology and it has already found industrial application in aerospace engineering, solar modules production, biomedicine and other state-of-the-art fields. Unlike vacuum plasmas, atmospheric plasmas don't require expensive pumping systems, complex transfer chambers from air to vacuum and can be applied to a wide variety of surfaces.

The HZB Detector laboratory team has assembled the experimental set-up on the base of Atmospheric Plasma Source (APS) and after adjustment of many system parameters has received promising results in boron-10 layers formation.

For comparison of the neutron absorption efficiency of 10B-based layers made by APS it is necessary to have reference layers of high quality created with vacuum plasma technique. For this purpose conventional magnetron sputtering was boosted to provide denser plasma with a higher fraction of boron ions. Boron-rich plasma leads to improved adhesion and higher density of formed layers. As a result high quality 10B reference layers were deposited at HZB using a special type magnetron sputtering and are now available for comparative measurements.

The results obtained so far show that this new atmospheric plasma system is very efficient as it allows very high deposition rates. The HZB detector team anticipates producing one m^2 neutron converter within few hours.

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