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P1.78: Development and validation of the KAERI-NDP system

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Neutron depth profiling (NDP) is an analytical technique used to determine the amount and distribution of light elements in materials. This method is beneficial for the study of thin films and surface layers. A sample is exposed to a thermal neutron beam in a vacuum chamber, and the emitted charged particles lose energy while passing through the material. The energy lost depends on the particle's path length, determined by the stopping power. Lithium, beryllium, boron, and sodium are commonly used in NDP because their neutron cross-sections are much larger than those observed in other particle-producing reactions. NDP is a straightforward technique that can be used to quantify the depth profiles of certain isotopes in various materials, including semiconductors, thin films, and lithium batteries.

The Korea Atomic Energy Research Institute (KAERI) is now developing the KAERI-NDP system, an upgraded version of the conventional NDP system using cold neutrons generated from the HANARO (High-flux Advanced Neutron Application ReactOr) research reactor. To analyze trace elements using the KAERI-NDP system, improvements were made by focusing on several points. First, a focusing lens was used to reduce the background signal caused by radioactive materials by minimizing neutron irradiation to the material around the sample and to increase the neutron flux in the sample. Also, the focal distance between the sample and the focusing lens was optimized. Second, shielding was designed inside and outside the vacuum chamber to block unwanted gamma rays that could interfere with the measurement. The shielding was carefully calibrated to provide the best possible signal-to-noise ratio, ensuring the system could detect even small changes in the neutron flux. Lastly, a neutron beam monitoring system was built using a thin boron film to improve the accuracy of the analysis. Since the neutron flux changes according to the output of the research reactor, correcting it through neutron beam monitoring is crucial. The KAERI-NDP system was tested and validated using the SRM-2137. Overall, the KAERI-NDP system represents a significant step forward in the field of NDP analysis. Its design and implementation might promise to contribute significantly to a wide range of scientific applications, including materials science, semiconductor manufacturing, and battery research.

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