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Depth-Resolved μSR Using Ultra-Slow Muons at J-PARC MUSE

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At the U-line in J-PARC MLF MUSE, ultra-slow muons (USM) are generated by laser ionization of thermal muonium (Mu) in vacuum. Mu drifts in vacuum with a Maxwellian velocity distribution reflecting the production target temperature; consequently, the USM obtained from Mu ionization are also possess correspondingly low energies. At the U-line, a high-temperature tungsten target (2000 K, corresponding to 0.2 eV) and a room-temperature silica aerogel (300 K, 25 meV) are used. These USM are focused and accelerated by electrostatic lenses and transported to the experimental areas. In the U1A experimental area, a muon spin spectrometer is installed. The implantation energy of muons into the sample can be controlled in the range of sub-keV to 30 keV by adjusting the voltage of a high-voltage stage on which the entire spectrometer is mounted. Whereas surface muons with an energy of 4 MeV, commonly used in materials science research, are suitable probes for bulk samples, USM are well-suited for measurements on thin film samples or near interfaces within materials. We successfully implanted muons selectively into a platinum layer (20 nm thickness) sandwiched by silica layers (10 and 40 nm thicknesses), as reported at the previous μSR2022 conference. In this study, depth-resolved measurements were performed by scanning the beam implantation energy. This contribution will present demonstration results of USM-μSR measurements on multilayer thin film samples.

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