Present Status of Multi-Channel Spin Detector Development

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Spin- and angle-resolved photoemission spectroscopy (SARPES) is an indispensable technique for investigating the spin-dependent electronic structure of materials, providing direct access to the energy, momentum, and spin of electrons [1]. Since the discovery of Rashba systems and topological materials, the demand for high-efficiency SARPES has steadily increased in condensed matter physics. In particular, very-low-energy-electron-diffraction (VLEED) based spin detectors, which offer approximately two orders of magnitude higher efficiency than conventional Mott-type spin detectors, have become widely implemented [2,3,4].

Recent efforts have extended VLEED-based SARPES toward time-resolved and spatially-resolved measurements [5,6,7]. However, in time-resolved SARPES using two-photon photoemission processes or in nano-scale spatially-resolved SARPES with focused beams, the photoelectron intensity is significantly reduced compared to conventional ARPES. As a result, spin-resolved band structure mapping measurements with single-channel VLEED detectors require prohibitively long acquisition times.

To overcome this limitation, we are developing a reflection-type multi-channel spin detector based on a VLEED scheme at HiSOR. The system consists of a hemispherical electron analyzer followed by a custom-designed spin lens. Photoelectrons preserving the two-dimensional energy-momentum (E_k-θ) distribution are incident on an oxygen-terminated Fe thin-film target, and the reflected electron image is amplified by a microchannel plate and recorded with a CCD camera. This design enables simultaneous spin detection over multiple momentum channels, potentially improving the overall efficiency by more than three orders of magnitude compared to conventional single-channel VLEED detectors.

The spin lens assembly, high-precision power supply system, and control software have been completed, and trajectory optimization of photoelectrons is currently in progress.

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