Towards a quantitative EMCD analysis

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Electron magnetic chiral dichroism (EMCD) is a transmission electron microscope (TEM) based technique which is capable of measuring the element specific magnetic properties of materials with a very high spatial resolution. The technique was introduced in 2003 [1] and was first experimentally proven in 2006 [2]. Over the last decade, spatial resolution could be improved towards atomic resolution and orbital/spin magnetic moment could be measured using EMCD [3][4][5][6][7], but still the routine-wise quantitative analysis of materials using this technique is challenging in practice. This is because this technique is highly orientation sensitive and even a small change in the orientation of the material over the measurement area may significantly affect the measurement. One difficulty in the EMCD technique consists in the very low signal to noise ratio (SNR) as well as the serial acquisition of the electron energy loss (EEL) signal at two chiral positions. Even a small drift of the specimen or slight modification of the sample under the electron beam can change the measurement conditions between the measurement of the EMCD signal on the two different so called chiral positions . A solution to the above mentioned problems is to install custom designed apertures in the TEM which could acquire both of the chiral signals in parallel. Beyond this more precise acquisition of the two EMCD signals, for a precise assessment of the EMCD signal, it is also important to determine the orientation of the sample at each measurement point in case of acquiring a STEM map for example.

Here, we design a new aperture containing two circular holes in it, i.e. a double aperture (DA) as shown in Fig. 1. and install it in one of the spectrometer entrance aperture (SEA) positions. This aperture is capable of acquiring both the chiral EELS spectra simultaneously in a special spectroscopy mode called qE mode [8] under 2 (or 3) beam condition (Fig. 2). Moreover, by changing from DA to a conventional SEA, the EDPs can be recorded immediately following the acquisition of the signal. The advantage of the DA is that we can get the chiral EELS spectra for EMCD measurements from exactly the same position of the specimen under the same geometrical and physical conditions and improve S/N ratio as compared to the apertureless qE mode. By acquiring the chiral EELS spectra and EDP at each scan point, one can directly relate the change in orientations to the change in real EMCD signal. This can help to develop a general methodology for the quantitative analysis of EMCD for different materials where a variation of the specimen from standard orientation could be compensated for by knowing the relative change in the EMCD signal as a function of orientation.

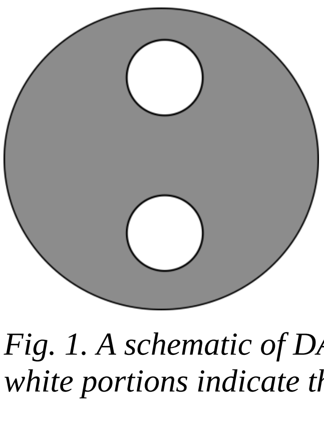

Fig. 1. A schematic of DA strip, the white portions indicate the open areas

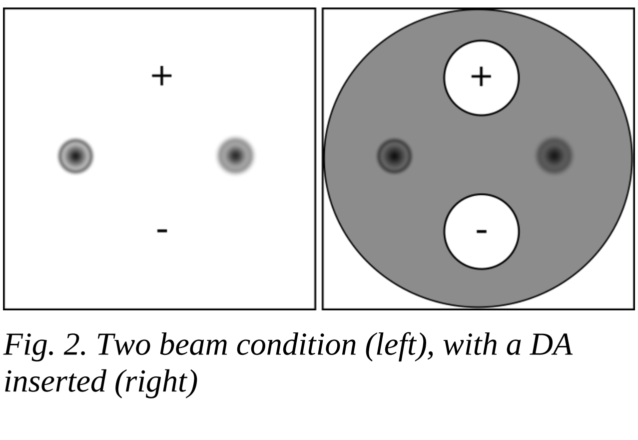

Fig. 2. Two beam condition (left), with a DA inserted (right)

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