ESRF

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$(\gamma, e\gamma)$-Spectroscopy	HC-127

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Report:

In $(\gamma, e\gamma)$ -spectroscopy the measured intensit y distributions are proportional to the 3-dimensional electron momentum density (EMD) of the investigated samples [1]. Experiments had already performed at different places showing the feasibility of these measurements. In the reported experiment it was possible for the very first time to measure the 3-dimensional EMD in a single experiment as a function of all 3 moment urn components. This enhancement was due to the first use of a 2-dimensional electron detector and read-out electronics enabling the coincident detect ion of the energy of the compton-scattered photon and 2 momentum components of the recoil electron. As a sample we choose a Si single tryst al from which we wanted to obtain two complete 3D datasets. In the experiment the incident beam was monochromatized by means of a uncooled triangular Si crystal used in horizontal Bragg reflection from 551 planes. The asymmetric cut was 1.5° and the crystal was bent to about 500 m thus focussing 23 mm of beam into a beamspot of $\approx$ 1 mm. The bandwidth was 0.5 % and a monochromatic flux of 3.7 x 10^{11}(5.7 x 10^{10}) ph/s/100 *mA* could be obtained at the sample for 139 and 180 *keV*, respectively. During the experiment we increased the incident energy in order to increase the energy of the recoil electrons. For the energy-resolved photon detection we used a single-element high purity Ge-detector with ΔE = *675 eV* at 140 *keV*. The electron detector is build of 33 Si-PIN-diodes, each 5 x 5 mm^2 and equiped with its own in-vacuum preamplifier and a rack-mounted main amplifier. The 2- dimensional detector matrix consists of 5 rows containing 5-7-9- 7-5 elements. The pitch between the pixels is 10mm. in both directions. The energy resolution per pixel of $\approx$ 5 — 6 *keV* is poor. The sample was a Si wafer with its surface normal parallel to the [100] direction and another [100] direction in the scattering plane. The wafer was etched in the center area to a thickness of 2.2 pm. In the experiment we oriented the surface normal +/ — 22.5° to the scattering vector $\vec{K} = \vec{k'} - \vec{k_o}$ with momenta $\vec{k_o}(\vec{k'})$ of the incident (scattered) photon. Coincidence countrates were 2.8 Hz (150 *mA)* for 139 *keV* incident energy with single countrates of 0.15 kHz and 50 kHz in the photon and integral electron detector, respectively.

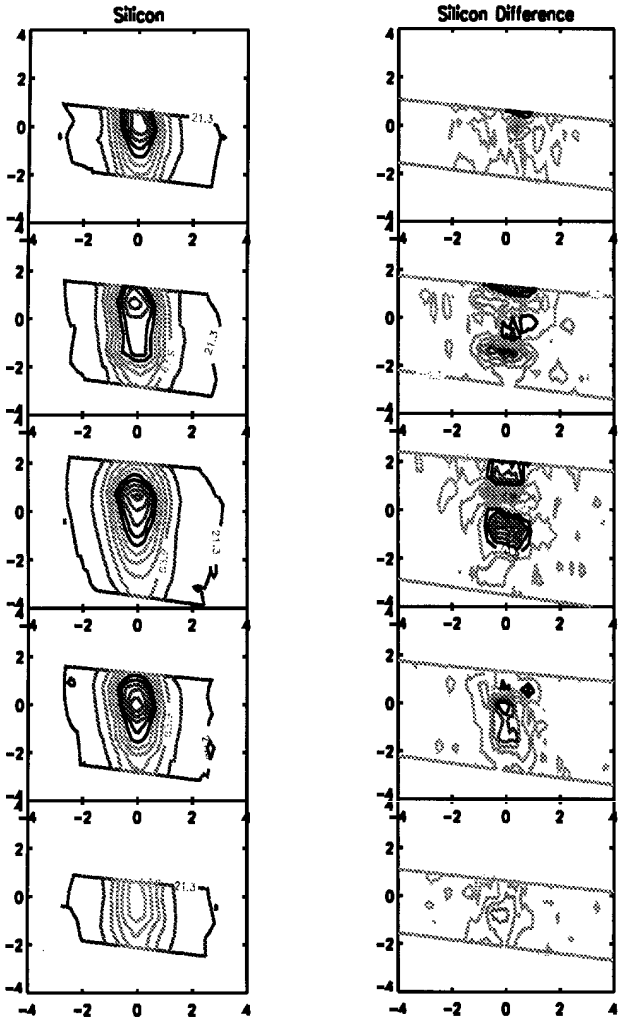

Figure: The left column shows contour plots of the 3D-EMD of Si in $p_z - p_x$–planes. $p_y = [p_y^0 \zeta \bar{p}_y^- \zeta \bar{p}_y^- \zeta \bar{p}_y^- \zeta \bar{p}_y^-$ from top to bottom. In the right column contour plots of the difference-EMD are shown for the same momentum coordinates.

The figure shows as a result of the measurements the direction EMD of Si aken for one direction and the difference-EMD after substraction of both directional measurements. The horizontal p_z– coordinate corresponds to the photon energy and the vertical p_x–coordinate is the horizontal component of the 2D-electron detector. The 5 plots reflect the 5 rows of detector pixels and stand therefore for different p_y—values. The inclination of the energy measurement when transformed to moment urn coordinates is a consequence of purely kinematical considerations [2]. Due to the thickness of the Si sample special care has to be taken of the electron multiple scattering. The final analysis of the data will result in a difference map, which is to be compared with well established results of different experimental techniques and/or theoretical calculations [3, 4]. But even in the very preliminary difference-EMD shown here, maxima along the p_x – direction can be seen, which corresponds to the direction the sample had been turned.

References

[1] Th. Tschentscher, J.R. Schneider, F. Bell, Phys. Rev. B48, 16965(1993)

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[3] C. Blaas, private communication, (1995)

[4] S. Tanigawa, Hyperfine Interactions 79, 575(1993)