The contrasts in backscattered electron (BSE) images were studied from the cross section of a heat-treated steel sheet using a scanning electron microscope (SEM) equipped with a conventional annular BSE detector (Σigma, Carl Zeiss NTS GmbH). The specimen used was heat-treated low carbon steel with an oxide layer mainly composed of magnetite (Fe₃O₄). A cross-sectional specimen was prepared by argon ion irradiation (IB-09010CP, JEOL Ltd.) after polishing with diamond suspension. BSE images were observed at primary electron energies (E_p) of 2 keV, 5 keV, 10 keV and 15 keV at various working distance from 2 to 15 mm for an identical area of the specimen (cross section). The take-off angles (θ; measured from the specimen surface) of the detector were estimated to be 35-45°, 39-53°, 50-63°, 66-75° and 73-79° (except 2 keV) from the geometry of the detector and the specimen. The variation of BSE intensities between crystal grains was calculated from the images. According to the results, high E_p enhances bulk information and Z contrast, whereas low E_p improves surface information and channeling contrast. High θ also enhances bulk information and Z contrast, whereas low θ improves surface information and channeling contrast. In the case of the lowest θ, topographic information was enhanced by shadowing effect on BSEs, in addition to the amplification of channeling contrast. These results regarding channeling contrast and Z contrast can be understood by the ratio of low-loss electrons (LLEs) to the inelastic BSE components detected; LLEs contribute to channeling contrast, and their ratio increases with decreasing E_p and θ. The systematic results obtained in this study are useful for controlling SEM conditions in order to select Z and crystallographic information separately in BSE images for practical materials of interest.

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Fig. 1: Schematic diagram showing dependencies of the BSE contrast on the θ and E_p. The areas where channeling contrast and Z contrast are enhanced in the BSE images are indicated by shaded and unshaded areas, respectively. The area where topographic information and channeling contrast are enhanced is indicated by dotted area.