Prior function designs for X-ray reconstructions from limited angular views

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The objectivity of three-dimensional imaging has placed X-ray Computed Tomography (CT) into an indispensable diagnostic method in clinical and industrial applications. Modern cone-beam industrial CT systems capable of high resolution at micron scale and beyond are becoming essential in materials research and development as well as structural diagnostics. Despite advances in the X-ray CT imaging field, high-resolution three-dimensional reconstruction of small details in objects with large in-plane dimensions has been a fundamental challenge for the conventional X-ray CT method. An alternative scanning geometry, where X-ray source and a detector move synchronously irradiating a specimen at an inclined angle, has been proposed to address this challenge. Reconstruction of X-ray CT data from projections at limited angular views presents a fundamental algorithmic challenge that cannot be resolved without using the prior information on the reconstructed data. This information can be included using iterative reconstruction methods by means of prior (or penalty) function that steers the optimized cost function towards the a priori known information on the solution. This work presents new designs of prior functions developed for reconstructing the radiography data obtained under the limited angular conditions. The new prior designs target reduction of shape distortion artifacts, common for laminographic reconstructions, as well as preservation of small features, such as voids, edge details, and high-density inclusions. The novel prior function designs will be demonstrated on the large aspect-ratio microelectronics components as well as the specimens with large planar dimensions. To accommodate CT scanning of such objects, a novel microfocus X-ray CT scanning device that rotates X-ray source and moves the detector synchronously while staying on the same side of the test specimen (Inclined CT), is introduced. This device allows scanning of critical areas of up to 3-meter-wide and potentially unlimited length specimens with high resolution required for identification of manufacturing and structural defects typical for modern composite structural elements used in the aerospace industry.