exiting from the collector optic pass to sample **80**, which optionally is on a rotating or translating apparatus **100**. The image generating x-rays **110** are received in the composite objective **120** (which preferably includes a Fresnel zone plate array, as described below) which creates a detectable image of the x-rays. The detectable image optionally is further refined using an aperture assembly **140**. X-ray image formation and acquisition apparatus **160** detects the x-ray image. The aperture assembly **140** is illustrated in more detail in FIG. **7**. The aperture assembly **140** includes an aperture structure (illustrated with the thick lines labeled **140** in FIG. **7**) having plural through-holes therein (illustrated with reference number **142** in FIG. **7**). The aperture assembly preferably is placed midway between the plane of the composite objective **120** (indicated in FIG. **7** as zone plate array including ZP_1 and ZP_2) and the image plane, where preferably the X-ray image formation and acquisition apparatus **160** is located. In FIG. **7**, the image plane is indicated with reference number **161**. Preferably the aperture assembly **140** is an order sorting aperture. The aperture assembly **140** blocks the positive and negative odd-order diffracted images except the first order from overlapping with the image forming first order x-rays, as illustrated in FIG. **7**.

In order to increase the proportion of the x-rays **50** that ultimately impinge on sample **80** (the x-rays that impinge, i.e. illuminate the sample **80** are illustrated with reference number **70**), it is preferred to use a grazing incidence collector in an ellipsoid shape for the collecting optic **60**. Preferably, the source of the x-rays **40** is viewed as a point source and is at one focus of the collecting optic **60** and the sample **80** is located at a second focus of collecting optic **60**. Improved control over the fidelity of the image of the source **40** may be obtained through the use of a Wolter optics as the collector optics **60**. Wolter optics combine a reflection off an ellipsoid with one off a hyperboloid.

In the preferred embodiment, the collecting optic **60** includes a cylindrical collector having a multi-layer coating **63** on a mirror **65**. A Wolter optic can be used. Such a multi-layer coating **63** serves to enhance the reflectivity of the mirror **65**. Such a collecting optic can collect incident x-rays **50** incident at an angle that is less than the critical angle of the mirror **65**. Using a multi-layer coating **63** can serve to increase the critical angle, thereby increasing the collection efficiency of the collecting optic **60**. A additional feature of the multi-layer coating **53** is that it serves to monochromatize the light. Preferably its bandpass is matched to an emission line of the x-ray source. The monochromized light is required to keep the resolution length scale of the Fresnel zone plate array **200** (discussed in greater detail below) small, due to the chromatic dispersion of the Fresnel zone plate array **200**. This is because the multilayer coating selects a single line from the emission spectrum and the intrinsic line width of the x-ray emission is small enough to suppress significant chromatic dispersion of the Fresnel zone plate.

Tomography may be performed in a raster scan mode or an imaging mode. If scanning is used, the length scale of the reconstructed volume elements are limited to the length scale of the spot size of the source, such as described in A. C. Kak and M. Slaney, *Principles of Computerized Tomographic Imaging,* IEEE Press, NY, 1986, which is referred to and incorporated herein by reference. If imaging is used, the length scale of the reconstructed volume elements are limited to the length scale of the resolution of the composite objective lens **120**, or the resolution of the x-ray image formation and acquisition apparatus **160** demagnified by the composite objective lens **120**, whichever is larger. Since the imaging mode is orders of magnitude faster than the scanning mode, scanning is not discussed here (although it does minimize the radiation dose to he sample).

The x-rays **70** from the collecting optic **60** are received by the sample **80**, as illustrated in FIG. **1**. The sample **80** is the item to be imaged in the x-ray imaging system of the present invention. In one example, the sample **80** is a silicon based wafer incorporating microcircuit elements and connectors disposed in a three-dimensional configuration within the processed wafer. Exemplary microcircuit elements are gates, transistors and interconnect wiring (that may be with or without defects) in x- y- and/or z-directions, although any elements may be included in the sample. Exemplary dimensions of such elements are 20–250 nanometers, although any other dimensioned elements may also be imaged using the present system.

The sample **80** is mounted on receiving apparatus **100**. Any rotating and/or translating receiving apparatus that can receive and retain the sample may be used. Preferably, the receiving apparatus can rotate or translate the sample **80** to allow different views to be generated. The rotating or translating apparatus **100**, positions the target (i.e. sample) by rotating or moving in linear directions (or combinations thereof) such as horizontally, vertically or diagonally. Exemplary rotation of the sample **80** is illustrated in FIG. **1** with arrow **90** and translation is illustrated with arrows **92** and **94**.

In one embodiment, a sample **80** is mounted on a receiving apparatus **100**. The sample includes a microchip having various gates, transistors, connectors etc. thereon. A microcircuit failure analysis is performed by imaging the sample **80** using the apparatus of the present invention. This analysis includes, for example determining if any of the interconnects have been or might become damaged.

Downstream of the sample **80** is a composite objective **120**. The composite objective **120** receives the x-rays **110** downstream of the sample **80** and creates a readable image in any desired fashion for receipt by the x-ray image formation and acquisition apparatus **160**. The composite objective **120** includes an array of micro-objectives **200**, which preferably includes a Fresnel zone plate array, such as illustrated in the exemplary embodiment of FIG. **4**. The composite objective **200** such as a Fresnel zone plate array, includes plural micro-objectives or Fresnel zone plates **210** arranged into any desired pattern. Any pattern incorporating plural micro-objective plates **210** may be used to achieve a desired imaging of the x-rays and the desired properties of the exit x-rays **130**. Any suitable type of micro-objective or Fresnel zone plate can be used in the array **200**, which suitably form an image of the x-rays **110**. For example, the Fresnel zone plates can be amplitude zone plates, phase zone plates, blazed zone plates, or any other suitable form of zone plate. Likewise any shape of micro-objective **210** or Fresnel zone plate may be used, such as annular, elliptical, square or rectangular. Alternatively, x-ray reflective or refractive lenses or zone plate lenses may be used in place of, or intermingled with the Fresnel zone plates. Each individual micro-objective or Fresnel zone plate creates an individual image received in the x-ray image formation and acquisition apparatus.

In one embodiment, the micro-objective array **200** is a portion of a two-dimensional hexagonally closed packed lattice, such as illustrated in FIG. **4A**. Such a pattern achieves six-fold rotational symmetry. Each micro-objective **210** or Fresnel zone plate **210** can have any desired shape, although it is preferred that each be generally circular. The individual micro-objectives **210** may be arranged to touch,