In one aspect the present invention comprises a tomography imaging system comprising a composite objective lens assembly comprising a plurality of Fresnel zone plates. Preferably the micro-objectives, such as the Fresnel zone plates, are arranged in an array, such as preferably one which is generally hexagonal and/or which is substantially planar. Alternatively, the array of micro-objectives is mounted on a structure imparting creating a curved composite objective.

In another aspect the present invention comprises a tomography imaging system comprising an x-ray source emitting light in a desired wavelength, a collector optic positioned to collect said light and transmit or reflect it, a sample holder positioning a sample to be imaged in the path of said light from said collector optic, a composite objective lens system including an array of Fresnel zone plates focusing said light in a desired fashion; and an imager receiving the x-rays from the sample via the composite objective lens system and forming an image based on them. Any form of x-ray source may be used, such as a laser plasma x-ray source or a synchotron or an x-ray tube that can achieve a point-like emission. It should be understood that other forms of composite objectives can be used.

In another aspect, the present invention comprises a method of forming an image of a sample comprising the steps of providing x-rays, exposing the sample to the x-ray (such as by illuminating the sample), and focusing the x-ray light downstream of the sample using a plurality of independent objective lenses comprising a plurality of Fresnel zone plates is preferred. As discussed above, the Fresnel zone plates preferably are arranged in an array such as a generally hexagonal and/or substantially planar array. The method of the present invention also may include, in another aspect, forming an image of a sample comprising the steps of providing x-rays, collecting the x-rays and transmitting or reflecting them in a desired fashion so that they can go to the sample, positioning the sample in the path of said transmitted or reflected x-rays, focusing the x-rays downstream of the sample using a composite objective lens such as comprising a plurality of Fresnel zone plates and creating an image using the x-rays, such as by detecting the x-rays using an x-ray detector such as an x-ray CCD camera or phosphor screen and visible light CCD camera to form 2D images, then optionally storing these 2D images in a computer readable memory, and forming a composite image, such as a 3D image of the sample.

Various forms of radiation or particle beams in addition to x-rays may be used in the present invention. For example, electrons beams, positrons, neutrons, photons, etc. may be used. When other forms of radiation are used it is preferred to select a radiation source specialized for generating that form of radiation and the collector and composite objective optics and image detector can be optimized for use with that form of radiation.

An advantage of the present invention is that plural images are formed at the same time and interference between the plural images is avoided.

These and other features and advantages of the present invention will be appreciated from review of the following detailed description of the invention, along with the accompanying figures in which like reference numerals refer to like parts throughout.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatic illustration of a system in accordance with the present invention;

FIGS. **2–3** illustrate alternative embodiments of an x-ray source in accordance with the present invention;

FIG. **4**A illustrates an exemplary micro-objective or Fresnel zone plate array in accordance with the present invention;

FIG. **4**B illustrates an exemplary micro-objective or Fresnel zone plate array in accordance with the present invention;

FIG. **5** is a front plan view of a Fresnel zone plate in accordance with the present invention;

FIG. **6** is a cross-sectional view of a Fresnel zone plate in accordance with the present invention;

FIG. **7** illustrates an aperture assembly in accordance with the present invention;

FIG. **8** is a flowchart of a method in accordance with the present invention; and

FIG. **9** is a flowchart of a method in accordance with the present invention.

FIG. **10** illustrates an x-ray image formation and acquisition apparatus in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In accordance with the present invention, a parallel x-ray nanotomography system and method are provided for forming an image of a target sample. As illustrated in FIG. **1**, an x-ray source **10** is provided. A laser-based x-ray source **10** is illustrated in FIG. **1**, which preferably is a point-like x-ray source. As seen in FIG. **1**, the laser-based x-ray source includes a laser source **20**, generating an output laser beam **30** and a laser plasma x-ray target **40**. Any laser source **20** may be used that can provide light at a desired wavelength, power level and beam quality. It is preferred that the laser source **20** provides an output beam **30** that has good beam quality (i.e. focused close to its diffraction limit).

A preferred x-ray source **10** is described in U.S. Pat. Nos. 5,003,779, 5,089,711, 5,539,764 and preferably includes as the laser source **20** a BriteLight™ laser available from JMAR Technologies, Inc. of San Diego, Calif., and as described in U.S. Pat. Nos. 5,434,875, 5,491,707 and 5,790,574, all of said patents being referred to and incorporated in this description by this reference. However, it should be understood that these particular laser sources and x-ray sources are mentioned as examples and any x-ray source generating a sufficient x-ray flux (i.e. photons per unit area, per unit time, per unit of solid angle) such as a point-like x-ray source at the sample **80** can be used. Alternative embodiments of x-ray sources are illustrated in FIGS. **2** and **3**. In FIG. **2**, a synchrotron **41** is provided, although this is not preferred because of the large size and high cost of currently available synchrotron. In FIG. **3**, an x-ray tube **24** is provided. In an exemplary embodiment, an x-ray flux of between 0.01 and 1 watt per square centimeter (cm^2) at the sample **80** is preferred. However, it should be understood that any x-ray flux suitable for generating an image at the x-ray image formation and acquisition apparatus **160** may be used and the acceptable x-ray flux may be above or below this range. In alternative embodiments an electron beam excited x-ray source is used instead of the laser beam source **20**. This may be particularly suitable for thicker samples **80**, which tend to require illumination with harder x-rays to ensure a good transmission through the specimen. Nevertheless, the use of harder x-rays also can have an adverse effect of decreasing the imaging resolution of the apparatus.

The x-rays **50** generated in the x-ray source **10** are collected and focused using collector optic **60**. The x-rays **70**