CLAIMS

1. A method of generating X-ray emission in the water window regime, comprising the steps of:

generating a beam of free electrons using an electron source;

directing the beam of free electrons onto a target crystalline material having a periodic material structure;

generating X-ray emission as a result of the interaction between the free electrons and the target crystalline material; and

directing the generated X-ray emission onto a reflective element for reflecting a selected photon energy within the water window;

wherein directing the generated X-ray emission onto the reflective element comprises controlling a tilt angle of the target crystalline material relative to the beam of free electrons and/or controlling an energy of the beam of free electrons.

2. The method of claim 1, wherein directing the generated X-ray emission onto the reflective element comprises controlling the tilt angle of the target crystalline material relative to the beam of free electrons, controlling the energy of the beam of free electrons, and

controlling a collection angle of the reflective element relative to the target crystalline material such that a Bragg condition is satisfied at the reflective element for the selected photon energy within the water window, and wherein the reflective element has a selected lattice spacing;

or

wherein the reflective material comprises a Kirkpatrick-Baez mirror or a Wolter mirror.

3. The method of claims 1 or 2, comprising directing an X-ray beam of the selected photon energy from the reflective element onto a sample, and optionally wherein directing the X-ray beam of the selected photon energy from the reflective element onto the sample comprises using a condenser optic to converge and focus the beam of the selected photon energy onto the sample.

4. The method of any one of the preceding claims,

comprising using a bent or curved crystal or a flat crystal with curved lattice planes as an X-ray lens for focusing the X-ray emission on the sample, and optionally wherein the target crystalline material comprises the bent or curved crystal or the flat crystal with curved lattice planes as the X-ray lens for focusing the X-ray emission on the sample;

or

comprising directing the X-ray emission towards the sample in a diverging fashion and comprising using a variable size pin hole to control an X-ray dose falling on the sample.

5. The method of any one of the preceding claims, comprising controlling an orientation of the target crystalline material at a selected tilt angle for optimizing X-ray flux onto the sample.

6. The method of any one of the preceding claims, wherein directing the generated X-ray emission onto the reflective element comprises shaping the X-ray spectrum lineshape falling onto the sample, and optionally comprising using a moveable beam stopper for shaping the X-ray spectrum lineshape falling onto the sample.

7. The method of any one of the preceding claims, wherein the reflective element comprises a further crystalline material having a periodic material structure, and optionally wherein the further crystalline material is configured with a curved surface onto which the generated X-ray emission is directed.

8. The method of any one of the preceding claims, wherein the reflective element is circular or a part of a circle or in a curved shape, to collect a conical radiation pattern from the target crystalline material and/or wherein the target crystalline material comprises a van der Waals crystal.

9. A system for generating X-ray emission in the water window regime, the system comprising:

an electron source for generating a beam of free electrons using an electron source;

a target crystalline material having a periodic material structure, wherein the electron source is configured for directing the beam of free electrons onto the target crystalline structure for generating X-ray emission as a result of the interaction between the free electrons and the target crystalline material; and

a reflective element;

wherein the system is configured for directing the generated X-ray emission onto the reflective element by controlling a tilt angle of the target crystalline material relative to the beam of free electrons and/or by controlling an energy of the beam of free electrons for reflecting a selected photon energy within the water window.

10. The system of claim 9, wherein the system is configured for directing the generated X-ray emission onto the reflective element by controlling the tilt angle of the target crystalline material relative to the beam of free electrons, controlling the energy of the beam of free electrons, and

controlling a collection angle of the reflective element relative to the target crystalline material such that a Bragg condition is satisfied at the reflective element for the selected photon energy within the water window, and wherein the reflective element has a selected lattice spacing;

or

wherein the reflective material comprises a Kirkpatrick-Baez mirror or a Wolter mirror.

11. The system of claims 9 or 10, further comprising an optical path for directing an X-ray beam of the selected photon energy from the reflective element onto a sample, and optionally wherein the optical path comprises a condenser optic to converge and focus the beam of the selected photon energy onto the sample.

12. The system of any one of claims 9 to 11,

comprising a bent or curved crystal or a flat crystal with curved lattice planes as an X-ray lens for focusing the X-ray emission on the sample, and optionally wherein the target crystalline material comprises the bent or curved crystal or the flat crystal with curved lattice planes as the X-ray lens for focusing the X-ray emission on the sample;

or

configured for directing the X-ray emission towards the sample in a diverging fashion and comprising a variable size pin hole to control an X-ray dose falling on the sample.

13. The system of any one of claims 9 to 12, further comprising a beam shaper for shaping the generated X-ray emission falling onto the monochromator, and optionally wherein the beam shaper comprising a moveable beam stopper.

14. The system of any one of claims 9 to 13, wherein the reflective element comprises a further crystalline material having a periodic material structure, and optionally wherein the further crystalline material is configured with a curved surface onto which the generated X-ray emission is directed, and optionally wherein the system is configured for controlling an orientation of the target crystalline material at a selected tilt angle for optimizing X-ray flux onto the sample.

15. The system of any one of claims 9 to 14, wherein the reflective element is circular or a part of a circle or in a curved shape, to collect a conical radiation pattern from the target crystalline material and/or wherein the target crystalline material comprises a van der Waals crystal or van der Waals heterostructure.