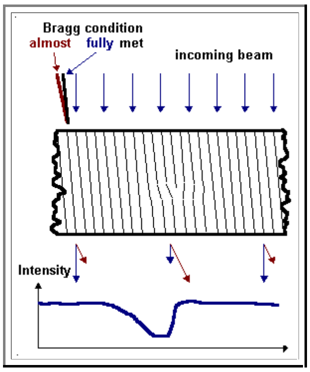
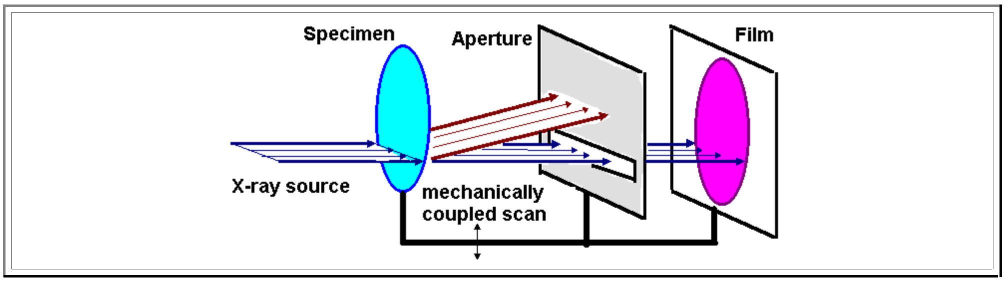
6.2 X-Ray Topography

- There are no efficient lenses for **X**-rays and therefore no **X**-ray microscopes. Still, there are ways to image defects with **X**-rays.
  - The essential part for imaging defects in crystals is the **diffraction** of the **X**-rays in the crystal lattice. This is in contrast to the conventional **X**-ray imaging technique in medical applications were the differential *absorption* of **X**-rays in differently dense tissue is used.
- The basic principle (which is also valid for imaging with electron beams in the transmission electron microscope) is shown below:
  - The specimen is oriented with respect to the incoming wave in such a way that the **Bragg-condition** for diffraction is only met (or nearly met) for just *one* set of lattice planes.
  - All defects with strain fields will locally deform the lattice and thus change the Bragg condition locally. The intensity of the diffracted beam will react to this and vary around defects. This is schematically shown below



  - In the example, the specimen is oriented in such a way that the Bragg condition in the perfect part of the crystal is almost, but not quite met. There will be no diffraction or, more quantitatively speaking, a rather low intensity of the diffracted beam. The primary beam thus is transmitted almost without any losses.
  - To the left-hand side of the edge dislocation, the strain field bends the lattice plane locally into the Bragg position. In this area the primary beam is strongly diffracted and loses intensity.
  - The intensity of the diffracted beam is mirror symmetric to the primary beam.

- For the imaging of defects (typically in **Si**-wafers, with or without processing) the following basic set-up is used.



- An **X**-ray source with a thin "one-dimensional" beam cross-section illuminates a line of the wafer. Only the primary beam (or, for dark-field imaging, the diffracted beam) is admitted through an aperture on the film. Wafer, aperture, and film are scanned through the beam.
- Some examples of **X**-ray topography are given in the following links; another one we have already encountered before.
  - Total view and resolution limit
  - Case study in bipolar technique
- The strengths and weaknesses of **X**-ray topography are quite apparent:

Strength	Weaknesses
• Imaging of large wafers with good resolution (ca. **5 µm**) possible • Detailed analysis (e.g. Burgers vectors) possible within limits • No specimen preparation necessary	• Very expensive • rather long exposure times even with powerful (typically **50 kW**) **X**-ray tubes • Resolution/sensitivity not good enough for single/small defects