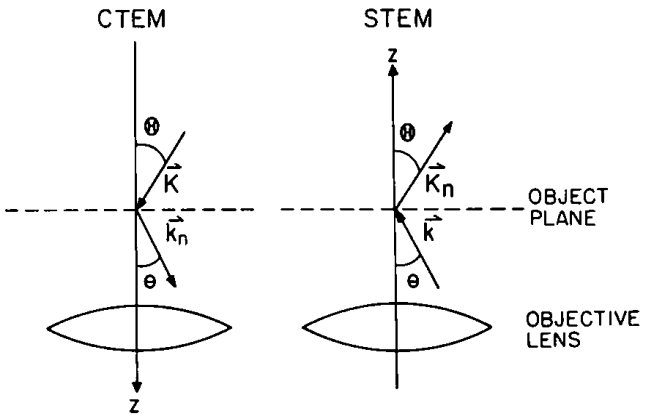
Advanced Analysis in TEM

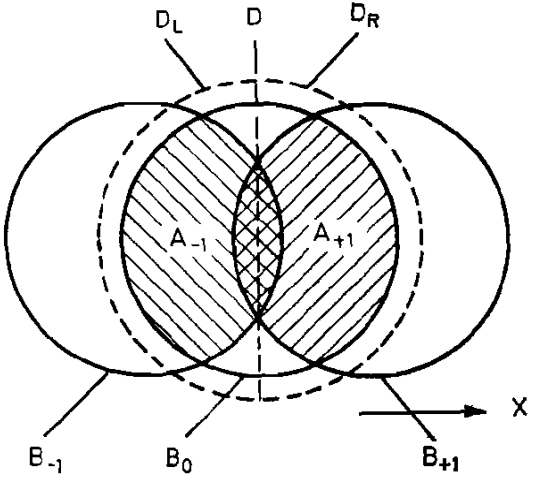
06/26/2020

Week 10

Differential Phase Contrast

Introduction to Differential Phase Contrast





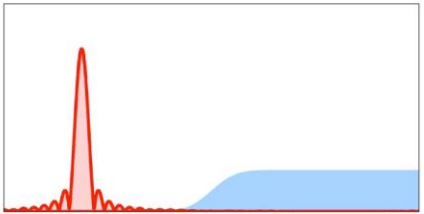
Coherent illumination in a CTEM, desirable for phase contrast imaging, has its analogue in the use of a very small detector in the STEM.

OPTIK, Vol. 41 (No. 4) 452-456 (1974)
Ultramicroscopy 2 (1977) 251-267

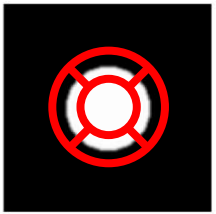
Differential Phase Contrast (Acquisition)

STEM probe amp.

Sample potential (phase shift)



Probe in Fourier space

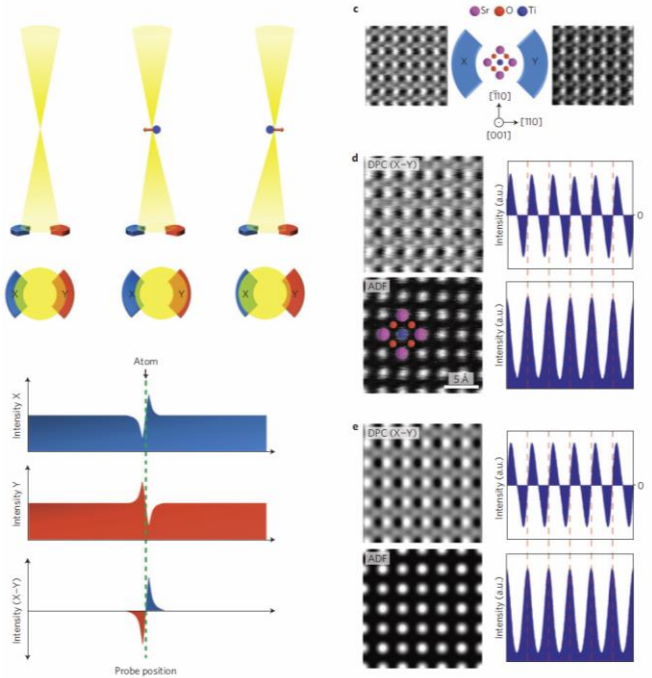


Therefore if we can measure the **shift** of the disk-shaped probe, we can estimate the **derivative** of the potential.

These shifts can be estimated from a **differential** measurement of the probe's top/bottom or left/right sides.

With a grid of these measurements, we can **numerically reconstruct** the 2D sample potential.

Differential Phase Contrast (High-Resolution with Segmented Detectors)



N Shibata et al.,Nature Physics **8**. 611 (2012)

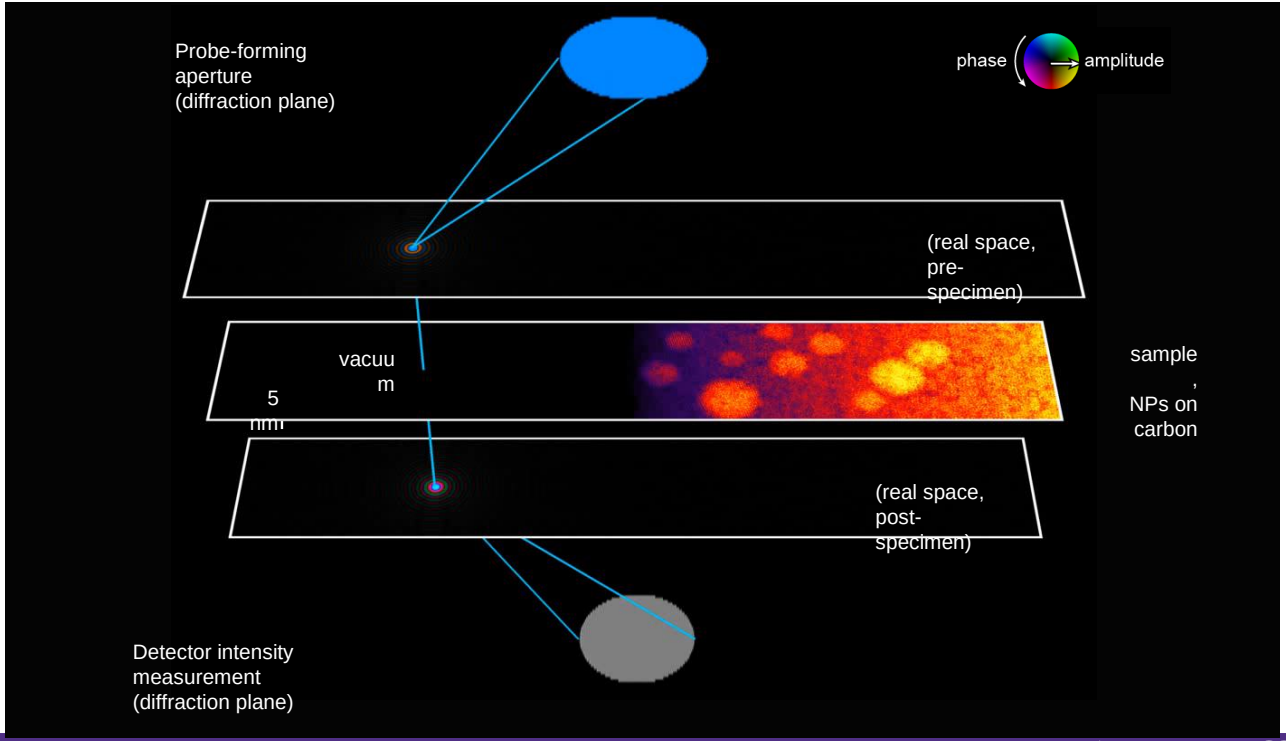
Advantages:

- Requires only a few detector pixels.
- Simple to implement/**Real Time DPC Imaging**
- Proven sensitivity to atomic contrast and (ideal, low res.) built-in electric field contrast (i.e. PN junction).

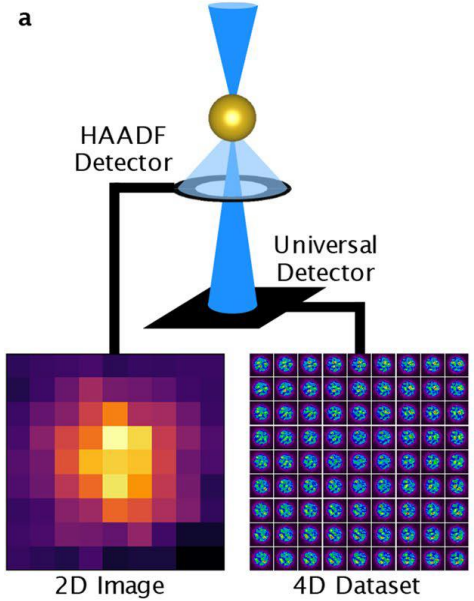
Disadvantages:

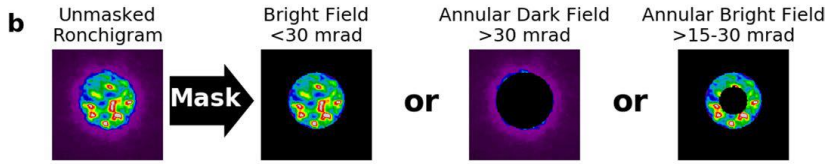
- **Not very dose efficient**.
- Interpreting images can be difficult (sample tilt, thickness variation).
- Requires many adjacent probes.

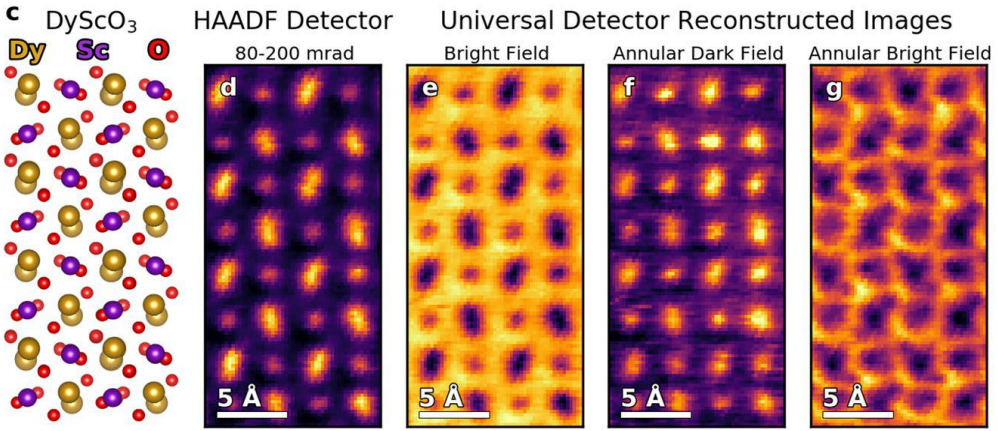
Differential Phase Contrast (Pixelated detectors)



Four-dimensional data collection







Hachtel et al. Adv Struct Chem Imag (2018) 4:10

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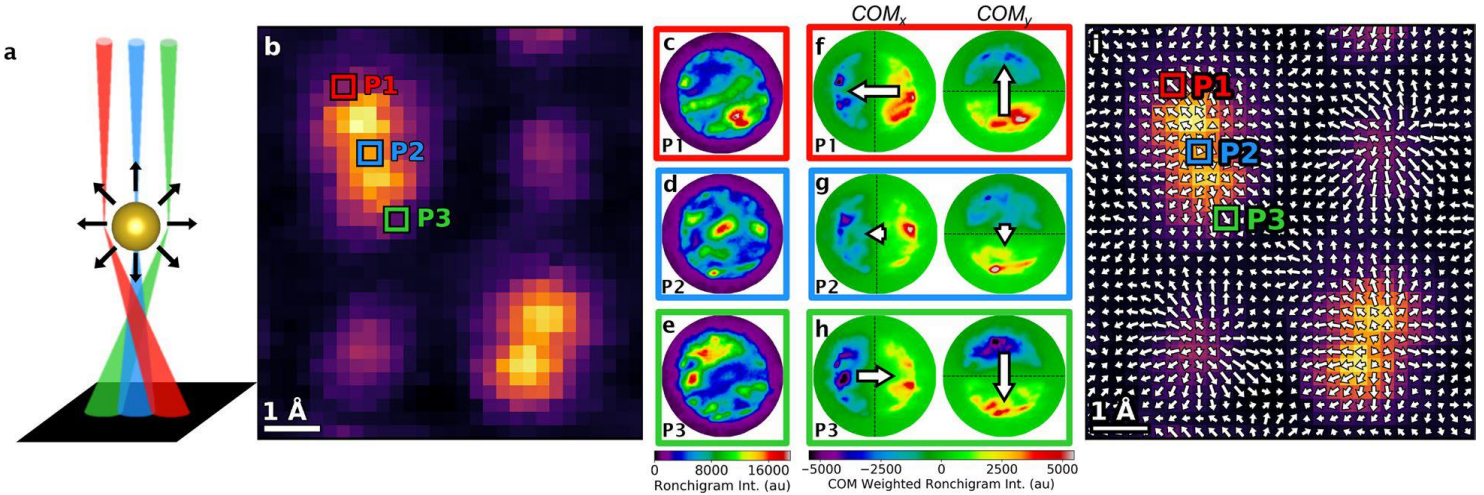

Hachtel et al. Adv Struct Chem Imag (2018) 4:10