Direct electron imaging of energy filtered EBSD patterns using a CMOS hybrid pixel detector

S. Vespucci[1], G. Naresh-Kumar[1], P. R. Edwards[1], D. Maneuski[2], V. O'Shea[2], A. P. Day[3], K. P. Mingard[4], A. Winkelmann[5] and C. Trager-Cowan[1]

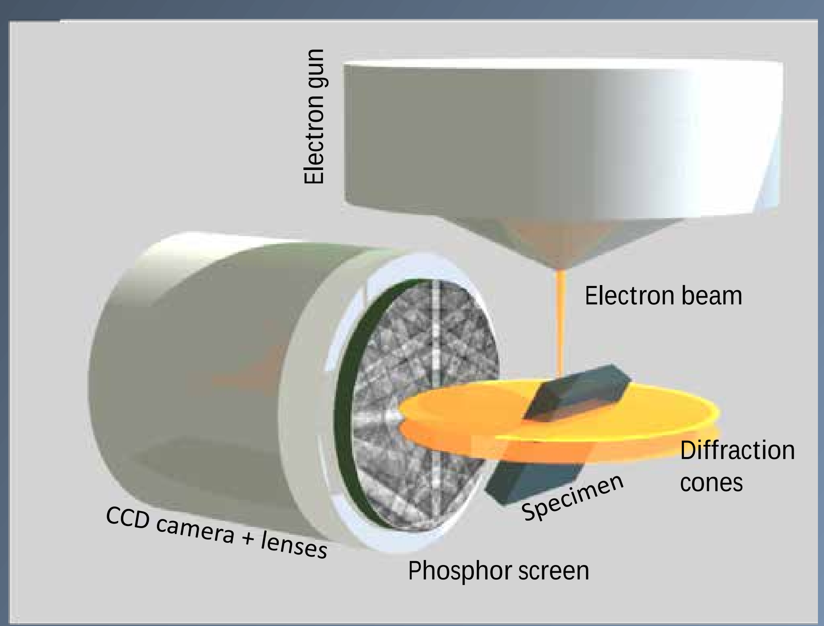
[1]Department of Physics, SUPA, University of Strathclyde, Glasgow, G4 0NG, UK
[2]School of Physics and Astronomy, SUPA, University of Glasgow, Glasgow, G12 8QQ, UK
[3]Aunt Daisy Scientific Ltd, Claremont House, High St, Lydney, GL15 5DX, UK
[4]National Physical Laboratory, Teddington, Middlesex, TW11 0LW, UK
[5]*Bruker-Nano*, Am Studio 2D, 12489 Berlin, Germany

1. Aim and Overview

The aim of this work is to advance the capabilities of the electron backscatter diffraction (EBSD) technique, by using a digital CMOS hybrid pixel detector, Timepix [1], for the direct, energy filtered acquisition of EBSD patterns (EBSPs). Direct electron imaging combined with energy filtering allows the technique to achieve unprecedented performance. The detail, contrast and sharpness in energy filtered EBSPs is greatly improved compared to conventionally acquired patterns. This enhancement is stronger for lighter, less dense material. Such an approach could extend the applicability of EBSD to materials for which conventional EBSD analysis is not presently practicable.

2. Introduction

EBSD is a scanning electron microscope based technique used to obtain information from crystalline materials (metals, ceramics, semiconductors, geological minerals).



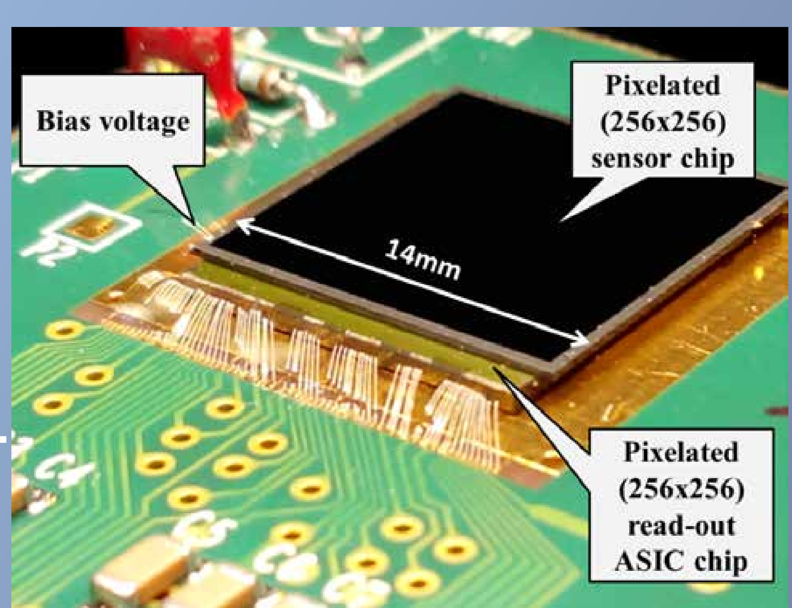
Conventionally an EBSD detector is composed of a combination of phosphor screen, optical lenses and CCD camera, used to image the diffraction pattern generated by backscattered electrons when a beam of electrons is focused in a point on the specimen surface.

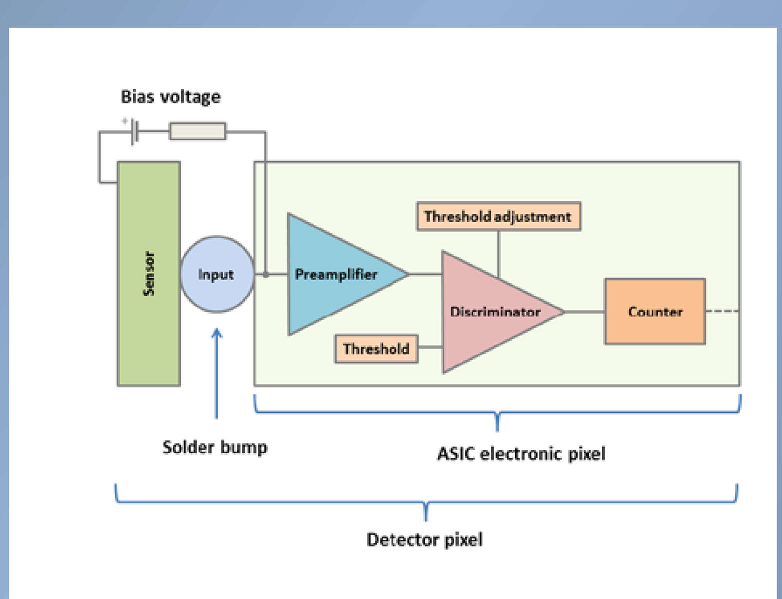
Limitations:

- Ø Inefficient conversion of electrons to light and back to electrons
- Ø Intrinsic light scattering and optical interference within the phosphor
- Ø Intrinsic noise of the CCD camera
- Ø Distortion of the pattern due to the detector optics
- Ø Inability to select electrons having a specific energy range

3. Timepix detector

One of the most important characteristics of the Timepix Detector [1], the discriminator, allows the detection of only those particles having an energy above a specific, tunable, threshold value. This allows energy filtering at the detector (electronics) level.





Advantages:

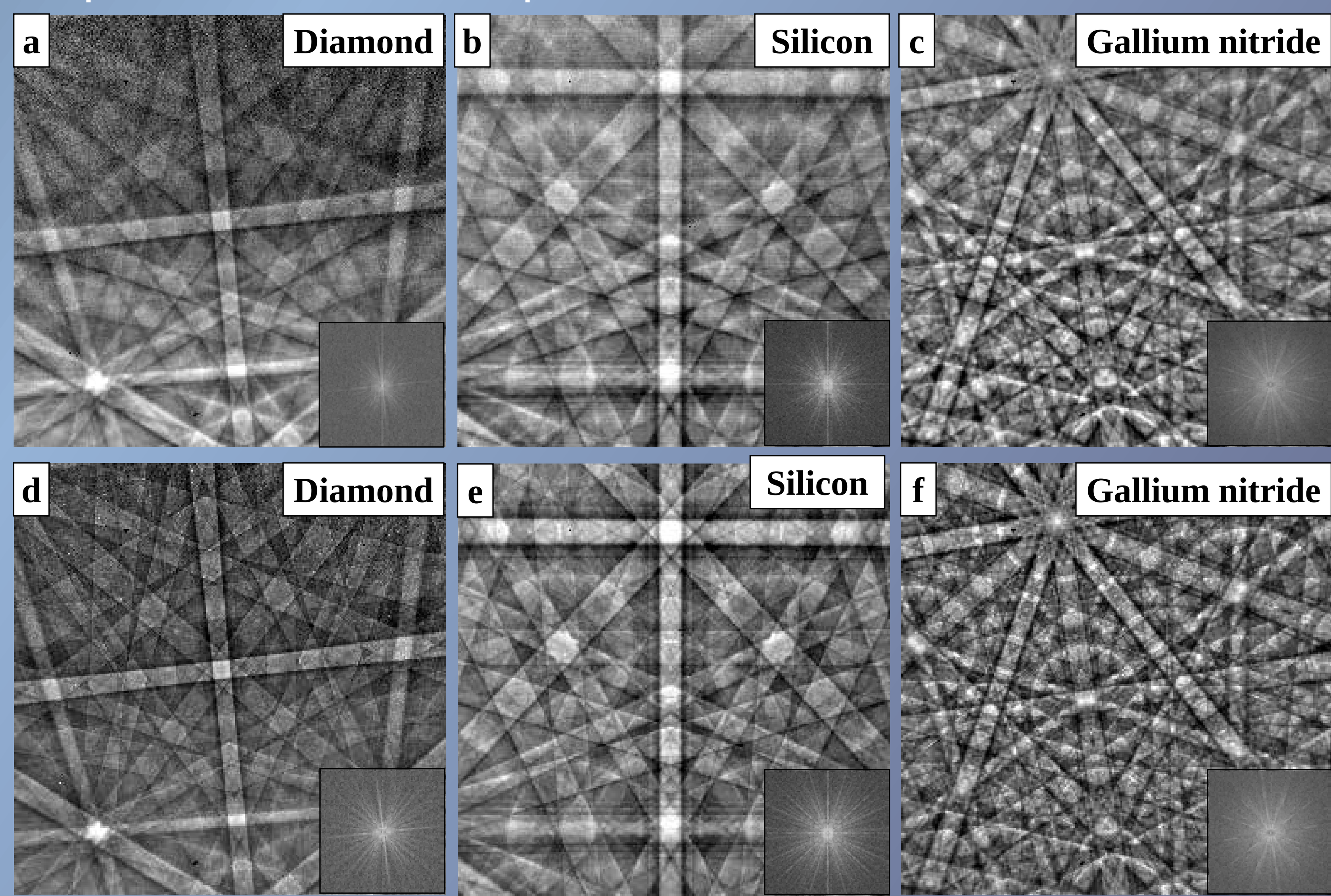
- Ø Direct electron imaging
  - Reduced exposure doses
  - Reduced beam energies
- Ø Working in noise-free condition
- Ø Energy filtering
- Ø Compact size

4. Experimental results

Energy filtered imaging: The largest contribution to the diffraction patterns comes from low-loss electrons [2], that is electrons with an energy within 10% of the energy of the primary beam. High-loss electrons contribute with a diffuse, feature-less, background which covers the diffraction features.

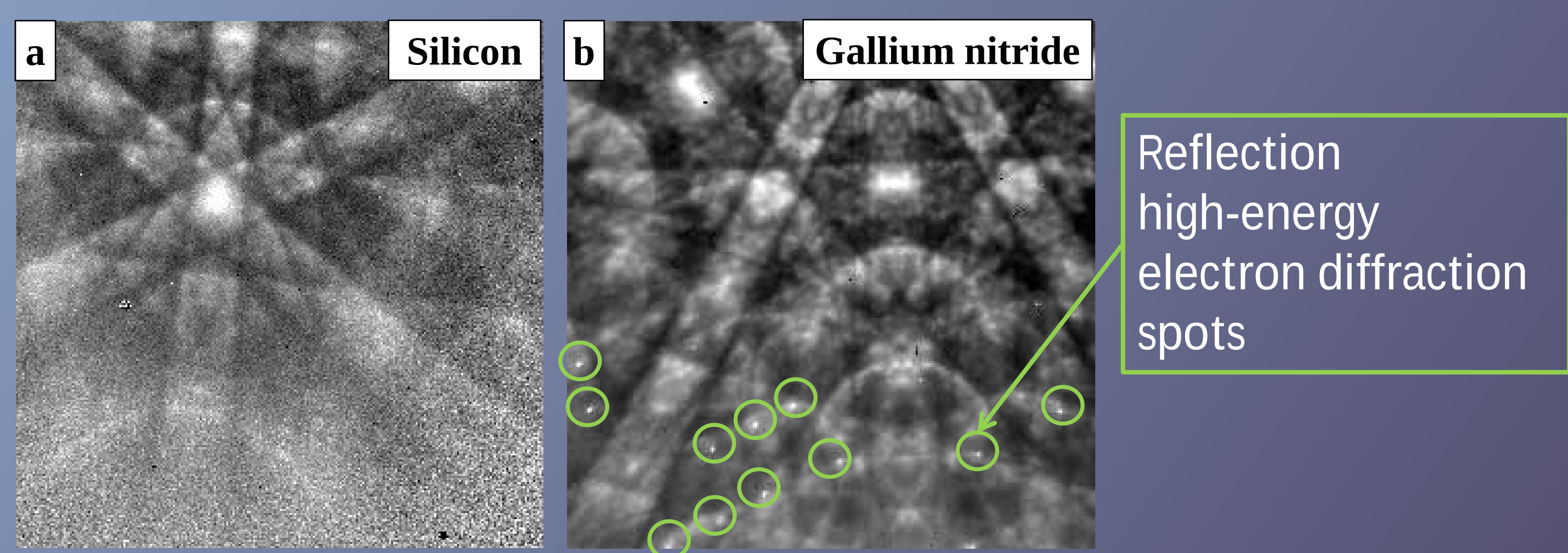
Advantages of the energy filtering:

- Ø Improved contrast and sharpness in energy filtered EBSPs
- Ø Higher order diffraction features are observed
- Ø Improvement in the depth and lateral resolution of EBSD



Beam energy: 20keV. Specimen tilt = 70°.
Specimen-detector distance: ≈1.5 cm.
(a-c) Threshold energy: ≈5 keV.
(d-f) Threshold energy: ≈ 19 keV.

Low energy imaging:



Specimen-detector distance: ≈ 1 cm. Specimen tilt = 70°.
(a) **Silicon**. Beam energy: 3.5 keV.
(b) **Gallium nitride**. Beam energy: 5 keV.

5. References

[1] https://medipix.web.cern.ch/medipix/pages/medipix2/timepix.php
[2] A. Eades et al, in *Electron Backscatter Diffraction in Materials Science*, A.J. Schwartz et al. (eds.), 53-63, Springer (2009)

6. Acknowledgments

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