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Large area EBSD mapping using a tilt-free configuration and direct electron detection sensor

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Advancements in direct electron detection (DED) sensors has allowed electron backscatter diffraction (EBSD) users to collect electron backscattering patterns (EBSPs) with an improved resolution, precision and with an extended range of experimental conditions [1][2]. As a result, it has been possible to revisit the idea of performing EBSD in a tilt-free configuration [3]. In this tilt-free geometry, the EBSD detector is inserted parallel to the specimen surface and perpendicular to the electron beam which facilitates the collection of electrons with an improved takeoff angle range. Fig. 1a) displays an image of the detector in an inserted position under the column (left) together with an example electron backscattering pattern (EBSP) acquired on a Tungsten specimen with an accelerating voltage of 8 kV (right). This approach helps to alleviate the typical limitations of the technique by removing the anisotropy in spatial resolution and need for dynamic focus or tilt correction, enabling the mapping of larger areas and improving the ease of use.

Without the requirement for a 70° tilt, the size of the specimen for EBSD analysis is limited only by the range of the lateral stage movement within the chamber. Fig. 1b) displays an image of a 6-inch wafer in the microscope's chamber with the EBSD detector inserted in the tilt-free configuration (left), alongside secondary electron (SE) images of the wafer with increasing magnification (right). A series of SE images were collected and stitched together using Thermo Scientific Maps Software to cover the range of the Si wafer and an example experimental Si EBSP collected with an accelerating voltage of 8 kV is presented alongside its corresponding dynamical simulation. This shows that by utilising the DED sensor in the tilt-free configuration it is now possible to extend the use of the technique to large specimen areas, whilst collecting high quality EBSPs.

In addition, measurements of the spatial resolution of the technique in this geometry has been performed using a Molybdenum bicrystal with well-defined Σ3 twin boundary. Fig. 2 displays a schematic diagram of the collection of EBSPs by sampling across the grain boundary (GB) trace with 5 nm steps with example EBSPs and indexed dynamical simulations (left) collected with an accelerating voltage of 15 kV. The mean physical resolution as obtained from a pattern quality (PQ) metric is also presented alongside the corresponding effective resolution which is estimated to be ~5 nm due to the successful indexing rate across the boundary [4][5].

We report on the benefits of using a DED sensor in a tilt-free configuration for the collection EBSD data over large areas with a high spatial resolution. This has the potential to allow for the use of the technique for applications that were not previously possible in a traditional geometry such as for the 6" wafer presented here.

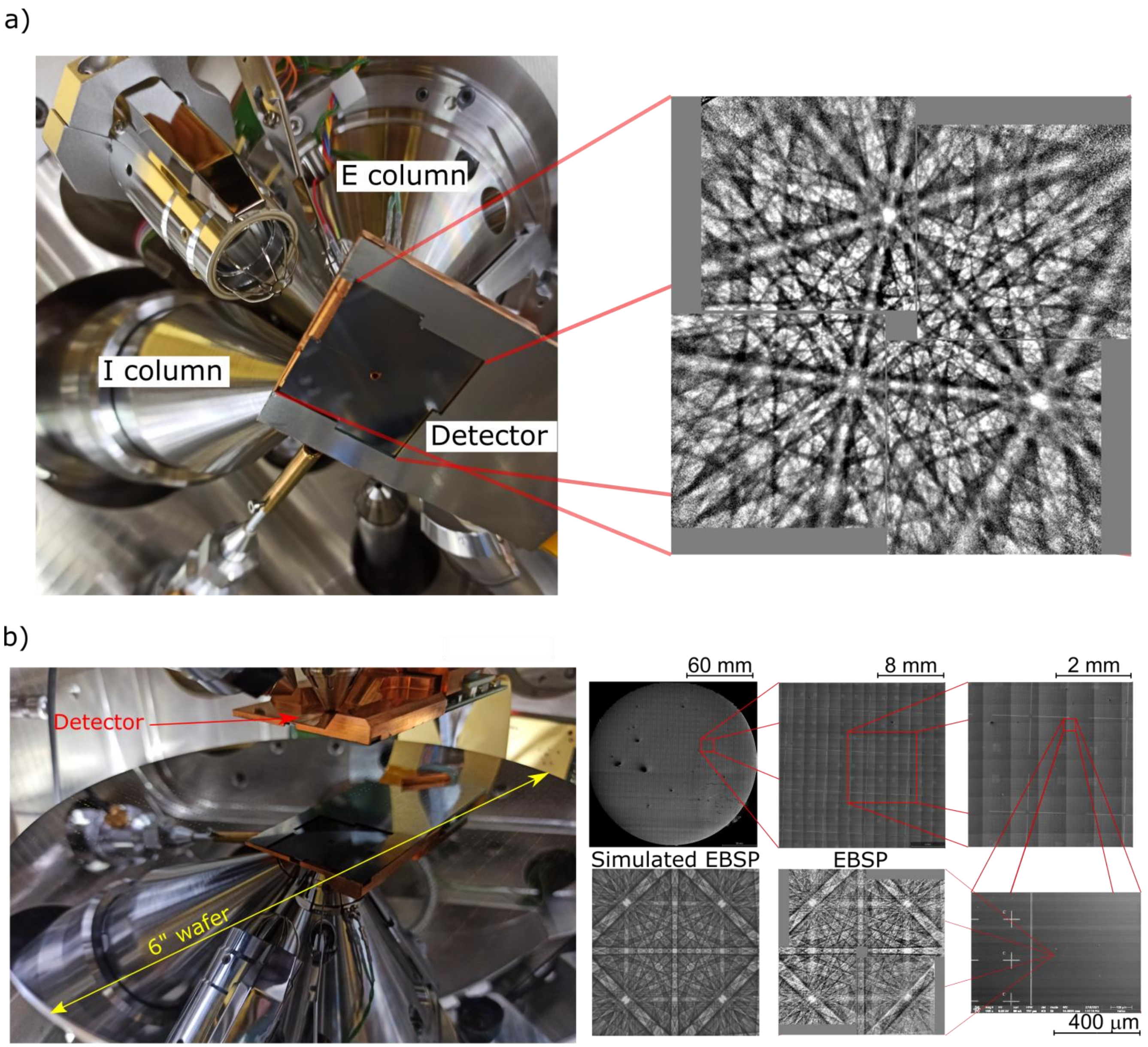

Figure 1. a) The Tilt-free EBSD setup photographed from below inside the SEM chamber (left) and example experimental EBSP collected from a Tungsten specimen with an 8 kV accelerating voltage (right). b) Image displaying a 6" wafer in the SEM chamber with the EBSD detector inserted in the tilt-free configuration (left). Stitched SE images with of Si wafer with increasing magnification and an example EBSP and corresponding dynamical simulation collected with an accelerating voltage of 8 kV (right). The SE images were collected and stitched using Thermo Scientific Maps Software.

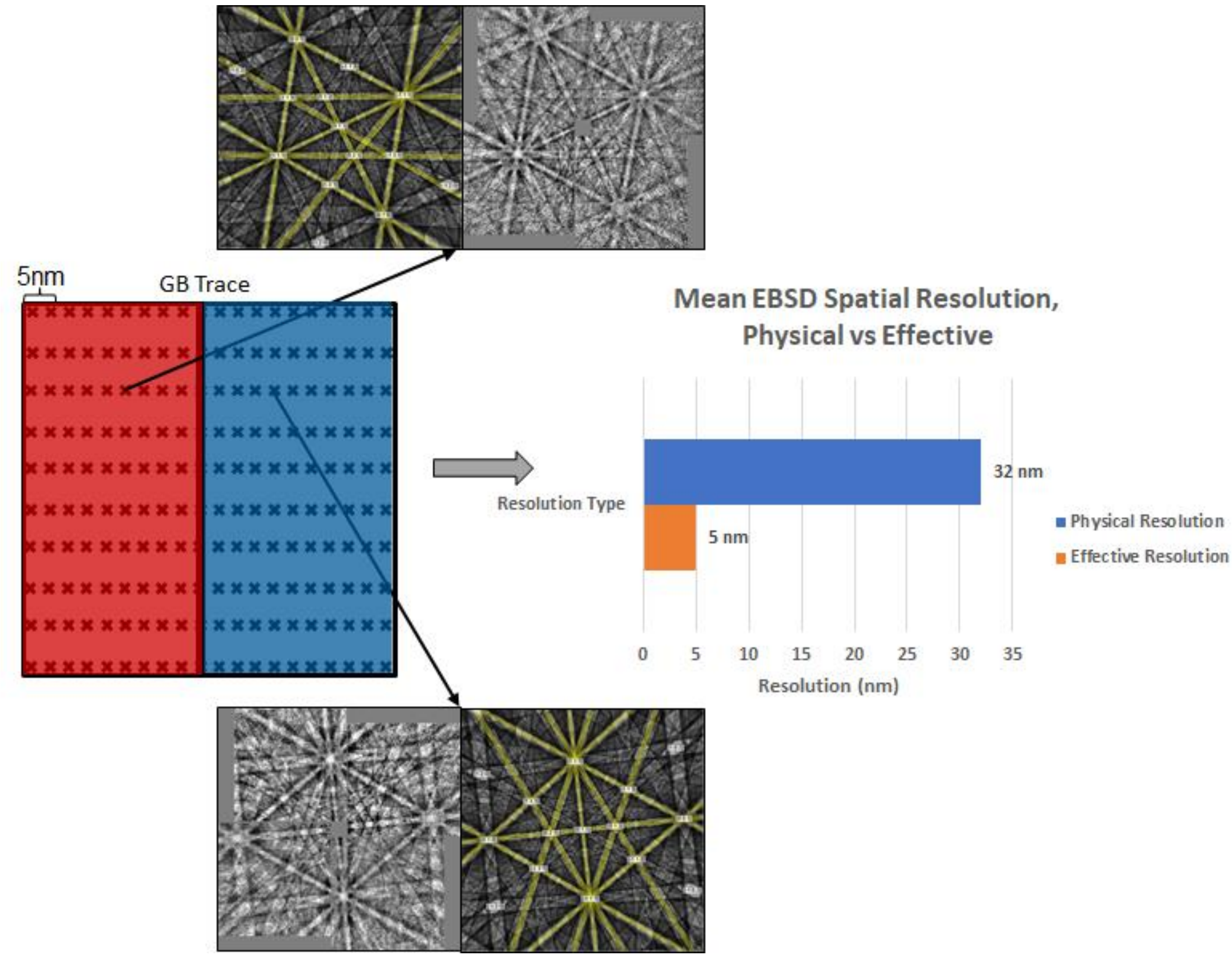

Figure 2. A schematic diagram of the resolution experiment setup with the collection of EBSD maps across a Molybdenum Σ=3 twin boundary (left). Example experimental EBSPs and their corresponding indexed dynamical simulations are displayed alongside a graph displaying the measured mean spatial resolution results (right).

References

[1] A. J. Wilkinson, G. Moldovan, T. B. Britton, A. Bewick, R. Clough, and A. I. Kirkland, "Direct Detection of Electron Backscatter Diffraction Patterns," *Phys. Rev. Lett.*, vol. 111, no. 6, p. 065506, Aug. 2013, doi: 10.1103/PhysRevLett.111.065506.

[2] X. Llopart, R. Ballabriga, M. Campbell, L. Tlustos, and W. Wong, "Timepix, a 65k programmable pixel readout chip for arrival time, energy and/or photon counting measurements," *Nucl. Instrum. Methods Phys. Res. Sect. Accel. Spectrometers Detect. Assoc. Equip.*, vol. 581, no. 1, pp. 485–494, Oct. 2007, doi: 10.1016/j.nima.2007.08.079.

[3] T. Vystavěl, P. Stejskal, M. Unčovský, and C. Stephens, "Tilt-free EBSD," *Microsc. Microanal.*, vol. 24, no. S1, pp. 1126–1127, Aug. 2018, doi: 10.1017/S1431927618006116.

[4] D. R. Steinmetz and S. Zaefferer, "Towards ultrahigh resolution EBSD by low accelerating voltage," *Mater. Sci. Technol.*, vol. 26, no. 6, pp. 640–645, Jun. 2010, doi: 10.1179/026708309X12506933873828.

[5] A. Tripathi and S. Zaefferer, “On the resolution of EBSD across atomic density and accelerating voltage with a particular focus on the light metal magnesium,” *Ultramicroscopy*, vol. 207, p. 112828, Dec. 2019, doi: 10.1016/j.ultramic.2019.112828.