DISLOCATION CORE PHASE IMAGING BY DBI

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A method to obtain the phase existing at the core of a dislocation in a crystal, the smallest physical singularity, is demonstrated using diffracted beam interferometry (DBI) [1]. The method also enables measurement of the strain at dislocation-dislocation intersections and the relief of strain of the dislocation at the surface. Additionally, the method is not sensitive to the thickness of the TEM specimen and should enable other phase contributors to be studied such as electrostatic charges that exist at the core in compound semiconductors and ceramics and core-decorating dopants such as carbon in steel. A dislocation in a single crystal Au specimen is used as an example. High contrast fringes within the interferogram were produced from the symmetric interference of the 220g and -2-2 0g beams, i.e., $\pm g_{hkl}$, interfered by means of a biprism, Fig. 1. The phase shifts within the interferogram represent the strain due to the displaced atomic planes around the dislocation core. In the perfect crystal, the equal but opposite Bragg diffracted beams cancel each other's phase. At the dislocation core the phase is not cancelled as each beam diffracts off a different atomic plane. This produces intensity contrast to the side of the dislocation core (Fig. 2a). The phase at the core doesn't cancel. Thus the phase shift at the core, dislocation intersections and surface (Fig 2 and Fig 3) can be obtained and expressed as,

$$\Delta\phi = \phi_{g_{hkl}} + \phi_{disl\_core} + \phi_{g_{\bar{h}\bar{k}\bar{l}}} + \phi_{disl\_core}$$

$$\Delta\phi = 2\phi_{disl\_core}$$

Phase imaging of the dislocation's core not being affected by the specimen's thickness is an advantage over intensity imaging methods such as lattice imaging and diffraction contrast imaging. This new imaging method will help to better understand dislocations in ways not before possible important for many reasons as dislocations have a strong influence on the physical, electrical, photonic, sensory and magnetic properties of materials but also a major influence on the rate and morphology of corrosion of materials. Their presence in the active region of electronic devices often causes their failure.

References

[1] Herring, R.A., G. Pozzi, and T. Tanji, "New Methods of Electron Holography and Interferometry Using Convergent Beam Electron Diffraction and an Electron Biprism (CBED+EBI)," *J. of Electron Microscopy,* Vol. 42, No. 4, pp. 267 – 272, 1993

Grants from UVic, NSERC Discovery, Engage and CRD, CFI and BCKDF are appreciated.

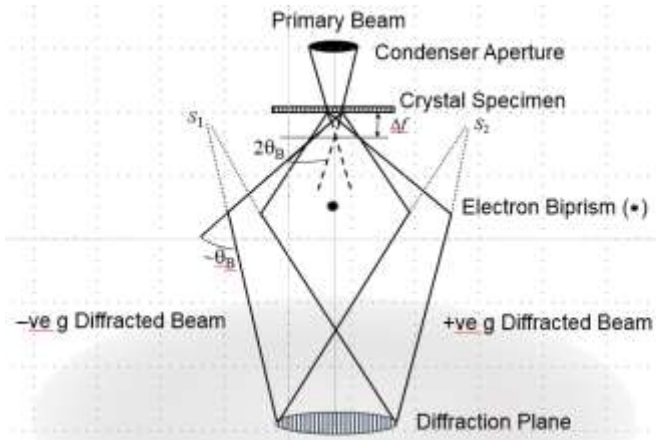

Fig. 1 – Configuration of DBI using the symmetric interference on axis of the 220g and -2-2 0g beams of Au by means of the electron biprism to image dislocations in the crystal specimen.

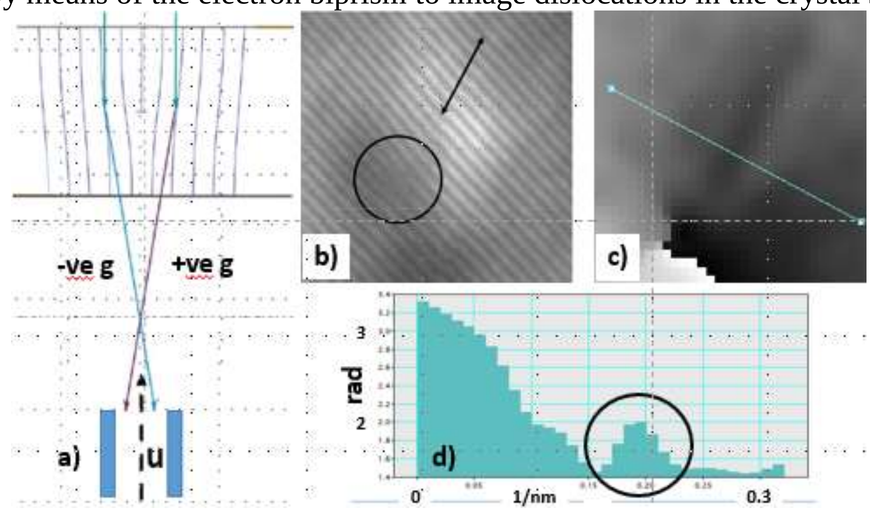

Fig. 2 – a) Displaced intensity contrast (blue bars) of Bragg diffraction occurs to one side of dislocation core, u, b) interferogram showing u (along arrow) and its singularity (circle), c) phase image revealing dislocation and d) phase shift revealed at the core of the dislocation (circled).

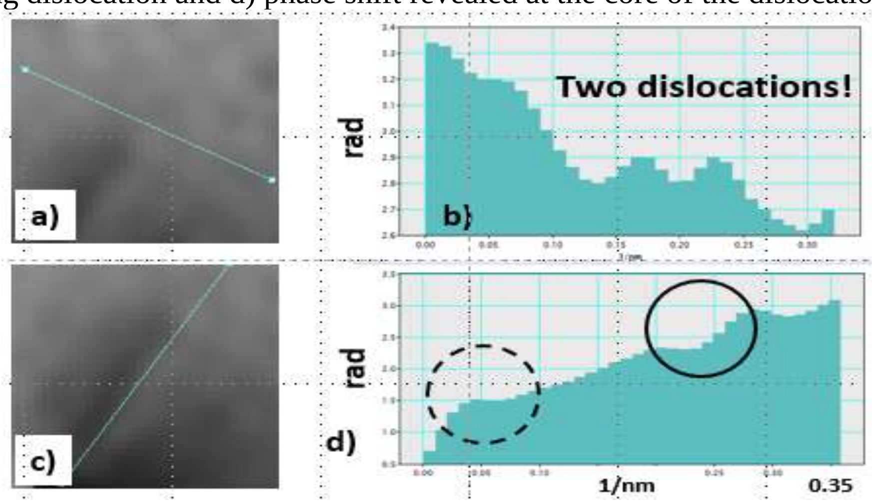

Fig. 3 a) and b) the phase shift of two dislocations intersecting c) and d) the phase shift along the length of the dislocation revealing the intersection point of the two dislocations in a) (within solid circle) as well as the relief of the dislocation's strain at the crystal's surface (dashed circle).