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Imaging Stress Induced Domain Movement and Crack Propagation by in situ Loading in the Transmission Electron Microscope

Oriol Gavalda-Diaz [1], Michele Conroy [2] and Finn Giuliani [2*]

[1.] Composites Research Group, Faculty of Engineering, The University of Nottingham, Nottingham, UK.
[2.] Department of Materials, Department of Materials, Imperial College London, UK.
* Corresponding author: f.giuliani@imperial.ac.uk

There has been much previous work to carry out deformation experiments within the TEM, particularly studying plastic deformation. However, in this work we want to show how setting up stable loading geometries can allow two different phenomena to be studied.

Firstly, crack propagation in brittle materials. Here a stable crack, arising from a double cantilever geometry, allows controlled crack propagation. This is crucial to study crack paths and crack deflection phenomena and to allow the data to be linked to larger scale SEM tests and first principles modelling.
Secondly, domain movement in ferroelectrics due to applied stress. In this case most of the previous work has concentrated on surface imaging after permanent deformation such as an indent. While here we have been able to image in both cross-section and *in situ* the effect of stress on the domain structure in Barium Titanate.

During initial loading, in the [010] direction, domains were seen to nucleate within the original domain structure, these continued to spread within the elastic and plastic zones as loading progresses and were aligned along the previously reported <110> directions. However, the original domain boundary could be observed to be curved away from the applied stress. Furthermore, on the edge of the elastic zone newly formed domains were seen to align parallel to the radial stress field, clearly moving away from the often observed <110> directions. After unloading, the vast majority of the domain structure recovered to its original state. Imaging was either carried out by bright field TEM or STEM at 300kV, while loads between 15-150 micro-Newtons were applied by a Hysitron Picoindenter operating with a wedge indenter.