# *Supplementary Material*

# *for*

# Dislocation toughening in single-crystal KNbO3

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**Figure S1** demonstrates the depth profiles of the Brinell zones. The depth is in all cases 400 – 500 nm over a diameter of 150 µm, which means the imprint is almost completely flat. Therefore, the effect of the slope on the Vickers indentation is negligible.



Figure S1. Depth profiles of Brinell zones with different cycle count measured by confocal LASER microscopy.

To confirm the Burgers vector, we have performed further characterization using the ***g·b*** analysis. In Table 1, the first row presents the possible directions of the Burgers vectors ***b***, while the first column shows the imaging condition via different ***g*** vectors. Then, the Burgers vector ***b*** of linear dislocations was determined by investigating the line contrast with the invisibility criterion of vector ***g·b***=0 based on the TEM images provided in Fig. S2.

One linear dislocation marked by a red dashed line does not reveal contrast or very weak contrast under ***g2***=$1\overbar{1}0$. Hence, the Burgers vector b yields ±a [$110$] or ±a [$001$]. Nevertheless, the linear dislocation provides strong contrast under ***g1***=$020$ and ***g3*** =$\overbar{2}00$, which means ***g·b***≠0. This dependence of the dislocation contrast on ***g*** demonstrates that the dislocation has ***b***=±a [$110$], which is consistent with literature [1, 2].

Table 1. Dislocation invisibility table from ABF-STEM images

|  |  |
| --- | --- |
|  | Burgers vector ***b*** |
| $$0 1 0$$ | $$1 0 0$$ | $$1 \overbar{1} 0$$ | $$1 1 0$$ | $$1 0 1$$ | $$1 0 \overbar{1}$$ | $$0 1 \overbar{1}$$ | $$0 0 1$$ | $$0 1 1$$ |
| ***g*** | $$0 2 0$$ | 0 | 0 | -2 | 2 | 0 | 0 | 2 | 0 | 2 |
| $$1 \overbar{1} 0$$ | -1 | 1 | 2 | 0 | 1 | 1 | -1 | 0 | -1 |
| $$\overbar{2} 0 0$$ | 0 | -2 | -2 | -2 | -2 | -2 | 0 | 0 | 0 |
|  | Calculation results of ***g·b*** |



Figure S2. ABF-STEM images featuring a linear dislocation along (a) the [001] zone axis with (b) g1=020; (c) g2=1-10; (d) g3=-200.

To emphasize the correlation between dislocation density and fracture toughness values measured using the ICL method, the toughness values are plotted into the dislocation density figure (Figure S3).



Figure S3. Dislocation density and fracture toughness as a function of number of cycles.

**References:**

[1] P. Hirel, A.F. Mark, M. Castillo-Rodriguez, W. Sigle, M. Mrovec, C. Elsässer, Theoretical and experimental study of the core structure and mobility of dislocations and their influence on the ferroelectric polarization in perovskite KNbO3, Physical Review B 92(21) (2015) 214101.

[2] M. Höfling, M. Trapp, L. Porz, H. Uršič, E. Bruder, H.-J. Kleebe, J. Rödel, J. Koruza, Large plastic deformability of bulk ferroelectric KNbO₃ single crystals, J. Eur. Ceram. Soc. 41(7) (2021) 4098–4107.