Liu, Lifeng; **Vainchtein, Anna**; **Wang, Yangyang**
Kinetics of a twinning step. (English) Zbl 1299.74012
Math. Mech. Solids 19, No. 7, 832-851 (2014).

Summary: We study the kinetics of a step propagating along a twin boundary in a cubic lattice undergoing an antiplane shear deformation. To model twinning, we consider a piecewise quadratic double-well interaction potential with respect to one component of the shear strain and harmonic interaction with respect to another. We construct semi-analytical traveling wave solutions that correspond to a steady step propagation and obtain the kinetic relation between the applied stress and the velocity of the step. We show that this relation strongly depends on the width of the spinodal region where the double-well potential is non-convex and on the material anisotropy parameter. In the limiting case when the spinodal region degenerates to a point, we construct new solutions that extend the kinetic relation obtained in the earlier work of Celli, Flytzanis and Ishioka into the low-velocity regime. Numerical simulations suggest stability of some of the obtained solutions, including low-velocity step motion when the spinodal region is sufficiently wide. When the applied stress is above a certain threshold, nucleation and steady propagation of multiple steps are observed.

MSC:

74A25 Molecular, statistical, and kinetic theories in solid mechanics
74J10 Bulk waves in solid mechanics

Cited in **1** Document

Keywords:

kinetic relation; twinning step; lattice model; radiative damping; spinodal region

Full Text: DOI

References:

[1] Bhattacharya K, Microstructure of martensite (2003)
[2] Bray D, Metll Mater Trans A 27 pp 3362– (1996) · doi:10.1007/BF02595429
[3] Hirth JP, Theory of dislocations (1982)
[4] Hirth JP, Metll Mater Trans A 25 pp 1885– (1994) · doi:10.1007/BF02649036
[5] Müllner P, Scripta Mater 49 pp 129– (2003) · doi:10.1016/S1359-6462(03)00219-7
[6] Abeyaratne R, J Mech Phys Solids 51 pp 1675– (2003) · Zbl 1048.74031 · doi:10.1016/S0022-5096(03)00069-3
[7] Tsai H, J Mech Phys Solids 49 pp 289– (2001) · Zbl 1102.74325 · doi:10.1016/S0022-5096(00)00035-1
[8] Zhen Y, J Mech Phys Solids 56 pp 496– (2008) · Zbl 1171.74401 · doi:10.1016/j.jmps.2007.05.017
[9] Zhen Y, J Mech Phys Solids 56 pp 521– (2008) · Zbl 1171.74402 · doi:10.1016/j.jmps.2007.05.018
[10] Sharma BL, Cont Mech Thermodyn 19 (6) pp 347– (2007) · Zbl 1160.74397 · doi:10.1007/s00161-007-0059-4
[11] Atkinson W, Phys Rev A 138 (3) pp 763– (1965) · doi:10.1103/PhysRev.138.A763
[12] Carpio A, Phys Rev E 67 pp 056621– (2003) · doi:10.1103/PhysRevE.67.056621
[13] Celli V, J Appl Phys 41 (11) pp 4443– (1970) · doi:10.1063/1.1658479
[14] Earmme YY, J Appl Phys 48 (8) pp 3317– (1977) · doi:10.1063/1.324215
[15] Flytzanis N, J Mech Phys Solids 38 pp 539– (1977) · doi:10.1016/0022-3697(77)90189-5
[16] Ishioka S, J Phys Soc Japan 30 (2) pp 323– (1971) · doi:10.1143/JPSJ.30.323
[17] Kresse O, J Mech Phys Solids 51 pp 1305– (2003) · Zbl 1077.74512 · doi:10.1016/S0022-5096(03)00019-X
[18] Marder M, J Mech Phys Solids 43 pp 1– (1995) · Zbl 0878.73053 · doi:10.1016/0022-5096(94)00060-I
[19] Slepyan LI, Models and Phenomena in Fracture Mechanics (2002) · doi:10.1007/978-3-540-48010-5
[20] Slepyan LI, J Mech Phys Solids 52 pp 1447– (2004) · Zbl 1159.74390 · doi:10.1016/j.jmps.2004.01.008
[21] Slepyan LI, J Mech Phys Solids 53 pp 407– (2005) · Zbl 1146.74336 · doi:10.1016/j.jmps.2004.08.001
[22] Truskinovsky L, SIAM J Appl Math 66 pp 533– (2005) · Zbl 1136.74362 · doi:10.1137/040616942

[23] Vainchtein A, Physica D 239 pp 1170– (2010) · Zbl 1189.37082 · doi:10.1016/j.physd.2010.03.007
[24] Vainchtein A, J Mech Phys Solids 58 (2) pp 227– (2010) · Zbl 1193.82042 · doi:10.1016/j.jmps.2009.10.004
[25] Crowley S, J Phys Chem Solids 39 (10) pp 1083– (1978) · doi:10.1016/0022-3697(78)90159-2
[26] Flytzanis N, Phys Rev Lett 39 (14) pp 891– (1977) · doi:10.1103/PhysRevLett.39.891
[27] Rosakis P, J Nonlin Sci (2013)
[28] Ishioka S, J Phys Chem Solids 36 pp 427– (1975) · doi:10.1016/0022-3697(75)90069-4
[29] Ishioka S, J Appl Phys 46 pp 4271– (1975) · doi:10.1063/1.321410
[30] Koizumi H, Phys Rev B. 65 pp 214104– (2002) · doi:10.1103/PhysRevB.65.214104
[31] Healey TJ, Proc R Soc A 463 pp 1117– (2007) · Zbl 1132.74033 · doi:10.1098/rspa.2006.1807
[32] Swart PJ, Arch Ration Mech Anal 121 pp 37– (1992) · Zbl 0786.73066 · doi:10.1007/BF00375439
[33] Celli V, J Phys Chem Solids 37 pp 1125– (1976) · doi:10.1016/0022-3697(76)90141-4
[34] Ishioka S, J Phys Soc Japan 36 (1) pp 187– (1974) · doi:10.1143/JPSJ.36.187
[35] Cserti J, Am J Phys 85 (15) pp 896– (2000) · doi:10.1119/1.1285881
[36] Kratovchil J, Czech J Phys B 13 pp 891– (1963)
[37] Weiner JH, Phys Rev 134 (4) pp 1007– (1964) · doi:10.1103/PhysRev.134.A1007