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An edge dislocation near a nanosized circular inhomogeneity with interface slip and diffusion. (English) Zbl 1406.74062

Eur. J. Mech., A, Solids 61, 122-133 (2017).

Summary: We study the transient elastic field induced by an edge dislocation near a nanosized circular elastic inhomogeneity in which the effects of interface slip and diffusion are incorporated into the model of deformation. Separate Gurtin-Murdoch surface elasticities are specified on the surface of the inhomogeneity and on the adjoining surface of the surrounding matrix. In addition, rate-dependent interface slip and diffusion are assumed to occur concurrently on the inhomogeneity-matrix interface. The ensuing interaction problem is solved using a simple yet effective method based on analytic continuation and a convenient decomposition of the proposed solution. In particular, our method allows us to circumvent the second-order tangential derivative taken with respect to the interfacial normal stress, typically a source of additional complication and often an obstacle to the solution of such problems. The original problem is reduced to two coupled linear algebraic equations and a number of mutually independent sets of state-space equations, the general solutions of which can be obtained by solving the associated generalized eigenvalue problem. The image force acting on the edge dislocation is derived using the Peach-Koehler formula. Corresponding stress and displacement fields as well as the image force are found to be dependent on four size-dependent dimensionless parameters (arising from the surface elasticities) and on two size-dependent parameters (having the dimension of time) arising from the incorporation of interface slip and diffusion and they evolve with an infinite number of size-dependent relaxation times.

MSC:

74A50 Structured surfaces and interfaces, coexistent phases
74E30 Composite and mixture properties

Cited in **2** Documents

Keywords:

inhomogeneity; edge dislocation; surface elasticity; rate-dependent slip; diffusion; relaxation time; image force; analytical continuation; state-space equation

Full Text: DOI

References:

[1] Antipov, Y. A.; Schiavone, P., Integro-differential equation for a finite crack in a strip with surface effects, Q. J. Mech. Appl. Math., 64, 87-106, (2011) · Zbl 1258.74185

[2] Chen, T.; Dvorak, G. J.; Yu, C. C., Size-dependent elastic properties of unidirectional nano-composites with interface stresses, Acta Mech., 188, 39-54, (2007) · Zbl 1107.74010

[3] Dundurs, J., (Mura, T., Elastic Interaction of Dislocations with Inhomogeneities. Mathematical Theory of Dislocations, (1969), American Society of Mechanical Engineers New York), 70-115 · Zbl 0208.27503

[4] Dundurs, J.; Mura, T., Interaction between an edge dislocation and a circular inclusion, J. Mech. Phys. Solids, 12, 177-189, (1964)

[5] Gurtin, M. E.; Murdoch, A., A continuum theory of elastic material surfaces, Arch. Ration. Mech. Anal, 57, 291-323, (1975) · Zbl 0326.73001

[6] Gurtin, M. E.; Murdoch, A. I., Surface stress in solids, Int. J. Solids Struct., 14, 431-440, (1978) · Zbl 0377.73001

[7] Gurtin, M. E.; Weissmuller, J.; Larche, F., A general theory of curved deformable interface in solids at equilibrium, Philos. Mag. A, 78, 1093-1109, (1998)

[8] Herring, C., Diffusional viscosity of a polycrystalline solid, J. Appl. Phys., 21, 437-445, (1950)

[9] Kim, K. T.; McMeeking, R. M., Power law creep with interface slip and diffusion in a composite material, Mech. Mater., 20, 153-164, (1995)

[10] Koeller, R. C.; Raj, R., Diffusional relaxation on stress concentration at second-phase particles, Acta Metall., 26, 1551-1558, (1978)

[11] Markenscoff, X.; Dundurs, J., Annular inhomogeneities with eigenstrain and interphase modeling, J. Mech. Phys. Solids, 64, 468-482, (2014)

[12] Muskhelishvili, N. I., Some basic problems of the mathematical theory of elasticity, (1953), P. Noordhoff Ltd Groningen · Zbl 0052.41402

[13] Onaka, S.; Huang, J. H.; Wakashima, K.; Mori, T., Kinetics of stress relaxation caused by the combination of interfacial sliding and diffusion: two-dimensional analysis, Acta Mater., 46, 3821-3828, (1998)

[14] Raj, R.; Ashby, M. F., On grain boundary sliding and diffusional creep, Metall. Trans., 2, 1113-1127, (1971)

[15] Ru, C. Q., Simple geometrical explanation of Gurtin-murdoch model of surface elasticity with clarification of its related versions, Sci. China, 53, 536-544, (2010)

[16] Sharma, P.; Ganti, S., Size-dependent Eshelby's tensor for embedded nano-inclusions incorporating surface/interface energies, ASME J. Appl. Mech., 71, 663-671, (2004) · Zbl 1111.74629

[17] Sofronis, P.; McMeeking, R. M., The effect of interface diffusion and slip on the creep resistance of particulate composite materials, Mech. Mater., 18, 55-68, (1994)

[18] Srolovitz, D. J.; Luton, M. J.; Petkovic-Luton, R.; Barnett, D. M.; Nix, W. D., Diffusionally modified dislocation-particle elastic interactions, Acta Metall., 32, 1079-1088, (1984)

[19] Steigmann, D. J.; Ogden, R. W., Plane deformations of elastic solids with intrinsic boundary elasticity, Proc. R. Soc. Lond. A, 453, 853-877, (1997) · Zbl 0938.74014

[20] Ting, T. C.T., Anisotropic elasticity-theory and applications, (1996), Oxford University Press New York · Zbl 0883.73001

[21] Wang, X.; Pan, E., A circular inhomogeneity with interface slip and diffusion under in-plane deformation, Int. J. Eng. Sci., 48, 1733-1748, (2010) · Zbl 1231.74033

[22] Wang, X.; Pan, E., Interaction between an edge dislocation and a circular inclusion with interface slip and diffusion, Acta Mater., 59, 797-804, (2011)

[23] Wang, X.; Schiavone, P., Interaction between an edge dislocation and a circular inhomogeneity with a mixed-type imperfect interface, Arch. Appl. Mech., (2016), (in press)

[24] Wang, X.; Wang, C. Y.; Schiavone, P., In-plane deformations of a nano-sized circular inhomogeneity with interface slip and diffusion, Int. J. Eng. Sci., 108, 9-15, (2016) · Zbl 1423.74191

[25] Wei, Y. J.; Bower, A. F.; Gao, H. J., Recoverable creep deformation and transient local stress concentration due to heteregeneous grain-boundary diffusion and sliding in polycrystalline solids, J. Mech. Phys. Solids, 56, 1460-1483, (2008) · Zbl 1171.74318