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COMMENT

Comment on 'Counterbalancing forces in electromigration'

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Abstract
Comment on the letter by J Hoekstra *et al* 2002 *J. Phys.: Condens Matter* **14** L137.

Hoekstra *et al* [1] recently presented a letter claiming that the net force on a metallic wire due to the passage of a steady-state current is zero, which is based on momentum-balance arguments. They reported this result and mentioned that that is possible because, in addition to electromigration driving forces acting on scattering centres, there are counterbalancing forces acting on the rest of the system. They have attempted to state these arguments in a way that imposes no restrictions on the structure, composition or temperature of the conductor. However, they presumed that there is a characteristic length scale, ξ, much less than any linear dimension of the metallic wire [1], such that after averaging over this length scale the properties of this wire are homogeneous. There are no restrictions on the nature of any disorder in it, either [1].

Based on previous results using both kinetic [2–4] and continuum mechanical approaches [5] or experiences [2–5], the author here raises a few arguments about their approaches.

(1) As there is a steady-state discharge or stationary flow of many electrons through the wire, there will be balancing between the net momentum flux and the wire wall (inner) resistance [2, 3] (considering V as defined in [1]). In general the net momentum flux is due to the field force acting along the wire-axis direction (thus electrons can flow through the wire). Depending on the specific entropy consideration and the interacting conditions between electrons and the wire wall (inner) [2], the stationary state can be reached for many electrons.

(2) Based on the coordinate system of the centre of mass (COM), there will be no phase dispersion or wave attenuation for some specific orientations of many (colliding and then departing) electrons during binary encounters, as thermal noise is imposed [4]. If the role of phonons still persists, electrons interacting with them subjected to a certain disorder (in the lattice) will not flow regularly or smoothly!
(3) Static and/or dynamic roughening of the interface between electrons and the wire wall (inner) will generate an irregular or secondary flux of electrons flowing along the wire-axis direction [5] in addition to the primary steady-state flow. Unless a certain symmetry is imposed, there should be a minor net flux of electrons transverse to the wire-axis direction [5].

The above arguments will normally influence the situations or conditions based on which Hoekstra *et al* claimed their results before [1].

References

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