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Electron-ion correlations in electromigration: Coulomb's law and Landauer transport at the nanoscale

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Electromigration has gained increased prominence in recent years, as the rise of nanoelectronics has given way to higher current and power densities in computing interconnects and devices. In this context we address the fundamental materials question: what drives electromigration at the nanoscale? Our understanding of the forces that drive electromigration has remained at an uneasy juncture between the mesoscopic semi-classical and atomistic quantum mechanical regimes. At the nanoscale an atomistic understanding of materials is required. Through first-principles quantum transport calculations we show that a self-consistent Laundaer transport framework provides much needed atomistic insight into the fundamental Coulombic forces which drive both current flow and electromigration at the nanoscale. These insights provide a general timely overview of the importance of electromigration in modern nanoelectronic devices and materials, not only from an operational perspective but also from a novel materials design perspective.