Defects, Corrugation and Temperature Govern Rarefied-Air Drag on Graphene Coatings

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Abstract

Developing low-drag materials is vital for aerospace and transportation applications[1]. Graphene, known for its super-lubricity, shows promise as a coating[2], yet its effect on gas–surface drag—particularly in rarefied flows of nitrogen (air's main component)—remains unclear. Here, we perform massive MD scattering trajectories of N_2 gas on alumina and graphene-coated alumina across temperatures and defect types concentration. From the generated dataset, we compute the Tangential Momentum Accommodation Coefficient[2] (TMAC), which directly relates to drag.

Our results[4] demonstrate that coating alumina with a graphene layer effectively reduces TMAC and, consequently, the drag force at the gas-surface interface, effect persists across the studied temperature range (Fig. 1a). The presence of higher defects of concentrations such as vacancies, divacancies, and Stone-Wales defects—substantially increases drag (Fig. 1b). Nevertheless, within the range of experimentally relevant defect concentrations, the TMAC of graphene-coated alumina increases only modestly. Therefore, even under realistic conditions where defects are unavoidable, graphene-coated alumina is expected to retain its ability to significantly reduce the TMAC and thus the drag force at the gas–surface interface.

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References

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Figures

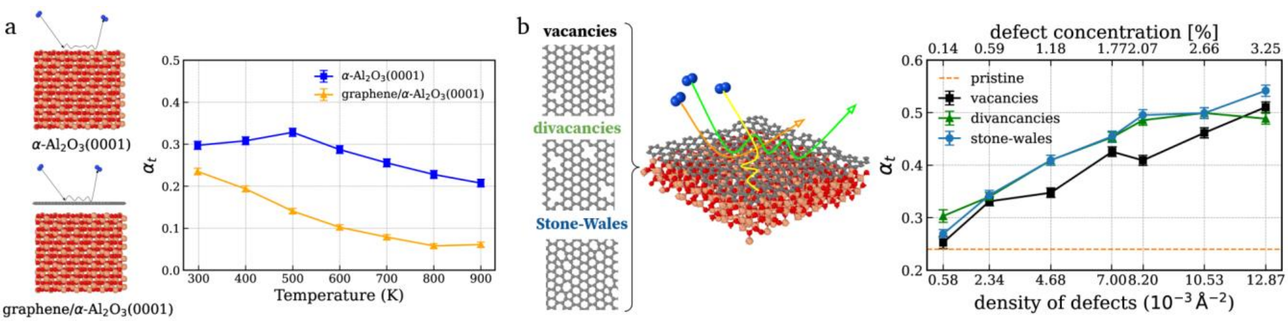

Figure 1: (a) TMACs at different temperatures for alumina (full blue line with square) and graphene-coated alumina (full orange line with triangles) surfaces. (b) TMACs at different density of defects on graphene; vacancies (black square points), divacancies (green triangular points) and Stone-Wales (light blue circle points). The orange dashed line corresponds to pristine graphene.