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Gas diffusion in and out of super-hydrophobic surface in transitional and turbulent boundary layers.[1] HANGJIAN LING, Johns Hopkins University, MATTHEW FU, MARCUS HULTMARK, Princeton University, JOSEPH KATZ, Johns Hopkins University — The rate of gas diffusion in and out of a super-hydrophobic surface (SHS) located in boundary layers is investigated at varying Reynolds numbers and ambient pressures. The hierarchical SHS consists of nano-textured, $\approx$100 μm wide spanwise grooves. The boundary layers over the SHS under the Cassie-Baxter and Wenzel states as well as a smooth wall at same conditions are characterized by particle image velocimetry. The Reynolds number based on momentum thickness of the smooth wall, $Re_{\Theta 0}$, ranges from 518 to 2088, covering transitional and turbulent boundary layer regimes. The mass diffusion rate is estimated by using microscopy to measure the time-evolution of plastron shape and volume. The data is used for calculating the Sherwood number based on smooth wall momentum thickness, $Sh_{\Theta 0}$. As expected, the diffusion rate increases linearly with the under- or super-saturation level, i.e., $Sh_{\Theta 0}$ is independent of ambient pressure. For the turbulent boundary layers, the data collapses onto $Sh_{\Theta 0} = 0.47 Re_{\Theta 0}^{0.77}$. For the transitional boundary layer, $Sh_{\Theta 0}$ is lower than the turbulent power law. When $Sh_{\Theta 0}$ is plotted against the friction Reynolds number ($Re_{\tau 0}$), both the transitional and turbulent boundary layer data collapse onto a single power law, $Sh_{\Theta 0} = 0.34 Re_{\tau 0}^{0.913}$. Results scaled based on Wenzel state momentum thickness show very similar trends.

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