Abstract Submitted
for the DFD13 Meeting of
The American Physical Society

Convective Air Mass Transfer in Submerged Superhydrophobic Surfaces: Turbulent Flow CHRISTINA A. BARTH, HOOMAN VAHEDI TAFRESHI, MOHAMED GAD-EL-HAK, Department of Mechanical & Nuclear Engineering, Virginia Commonwealth University, Richmond, Virginia 23284-3015 — Longevity of entrapped air is an outstanding problem for using superhydrophobic coatings. Herein, we analyze from first principles a mass transfer problem. Using integral methods, we are able to extend our laminar flow solution presented last year to turbulent flows. We introduce an effective slip to the hydrodynamic boundary layer using a modified 1/7-power law velocity profile. We then introduce the hydrodynamic solution to the two-dimensional problem of alternating solid–water and air–water interfaces to determine the convective mass transfer of air's dissolution into water. This situation simulates spanwise microridges. The decoupled mass-transfer problem is solvable using an approximate integral method previously optimized by Reynolds et al. (1958). A mass-transfer correlation is derived as a function of the surface geometry (or gas area fraction), Reynolds number, and Schmidt number. Longevity, or time-dependent hydrophobicity, can be estimated from the resulting mass-transfer correlation. As expected, turbulence greatly enhances the rate of convective mass transfer, and thus superhydrophobicity is not maintained as long as it would under corresponding laminar flow conditions.

Mohamed Gad-el-Hak
Department of Mechanical & Nuclear Engineering,
Virginia Commonwealth University, Richmond, Virginia 23284-3015

Date submitted: 08 Jul 2013 Electronic form version 1.4