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Failure Mechanisms of Air Entrainment in Drop Impact on Lubricated Surfaces[1] MIN PACK, HAN HU, DONG-OOK KIM, Drexel University, ZHONG ZHENG, HOWARD STONE, Princeton University, YING SUN, Drexel University, DREXEL UNIVERSITY TEAM, PRINCETON UNIVERSITY TEAM
— Lubricated surfaces have recently been introduced and studied due to their potential benefit in various applications. Combining the techniques of total internal reflection microscopy and reflection interference microscopy, we examine the dynamics of an underlying air film upon drop impact on a lubricated substrate. In contrast to drop impact on solid surfaces where asperities cause random breakup of the entraining air film, we report two air film failure mechanisms on lubricated surfaces. In particular, using thin liquid films of high viscosity, we show that air film rupture shifts from a randomly driven to a controlled event. At low Weber numbers (We) the droplet bounces. At intermediate We, the air film fails at the center as the drop top surface crashes downward owing to impact-induced capillary waves; the resulting liquid-liquid contact time is found to be independent of We. In contrast, at high We, the air film failure occurs much earlier in time at the first inflection point of the air film shape away from the drop center, where the liquid-liquid van der Waals interactions become important. The predictable failure modes of the air film upon drop impact sheds light on droplet deposition in applications such as lubricant-infused self-cleaning surfaces.

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