Surface nanobubbles and micropancakes

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PREFACE

Surface nanobubbles and micropancakes

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When looking at a wetted surface with a technique that can probe the nanoscale, a high surface coverage of gas bubbles is often revealed. So what? Well, if we believe in classical diffusion, these bubbles should dissolve in microseconds, but in reality they are found to remain stable for as long as anyone has observed (five days thus far, which is 10–11 orders of magnitude longer than would be expected). As well as the obvious question of why the lifetime is so long, and also the question of how the bubbles nucleate in the first place, we rapidly find ourselves asking can we use the bubbles to our benefit? A clear example would be in controlling slip in micro/nanofluidics: effectively, replacing a solid wall with a 'gassy' wall replaces the no-slip boundary condition with one of slip. Several other potential applications have also been suggested and nanobubbles have, in fact, already proven useful in the antifouling world.

Returning to fundamentals, another near-wall gas domain has also come to light through our investigations into nanobubbles. The micropancake is thought to be a quasi-2D dense adsorbate of gas molecules (i.e. N_2 or O_2) which grows epitaxially on the surface. New questions now include: why are micropancakes stable, how do they form, and what is their relationship with nanobubbles?

Progress is being made in this field and, as with all new topics, the community is rapidly converging toward a standard set of 'minimum' requirements for scientific reporting. For example, taking single-shot atomic force microscopy data is almost definitely no longer sufficient to be additive to the field (there are far too many unrepeatable single-shot measurements in the literature which are too often used as 'evidence', even though there are a seemingly equal number of single-shot measurements that may disagree). Just quoting a 'set-point' is now also insufficient (both set-point and free (or interaction) amplitude are required to know the applied force of an AFM)—hard core statistics with real numbers are now what matters. Also, carrying out molecular dynamics simulations with either zero-Kelvin walls or Lennard–Jones (LJ) potentials is almost definitely insufficient (the first necessarily forces the production of micropancakes, whilst for the second the community knows that using 'real' water models most often gives different results to their simplistic LJ counterparts). This cautionary note also extends to the new wave of experiments using optical visualization: yes we can now access fast dynamics, but (and I am writing from personal experience) we have an even bigger and necessary job to prove that the objects are not droplet contamination from, e.g. oil (AFM allows us to 'poke' bubbles and coalesce them; ATR allows us to 'see' that the bubbles contain gas; no such probe exists for optical measurements).

I think in the future we will see many strong contributions to the field where a combination of several techniques is used to tell a coherent story—the level of complexity and rigor must advance in order for the field to follow. It is great to see some of the contributions to this special section taking a closer look at the interpretative difficulties that are involved in the field, but which are, we hope, close to being understood.

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