Effect of Surface Wettability on Marangoni Flows Generated by Localized Plasmon Resonance

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Here an investigation is conducted into the effects of surface wettability on the nature of Marangoni flows at micron scale bubbles [1]. Water vapor bubbles are generated by localized plasmon resonance in irradiated, Au nanoparticle (NP) coated surfaces. Prior to irradiation self assembled monolayers (SAMs) are used to coat NP films, changing their wettability. Film wettability, measured by water contact angle, can be adjusted by vacuum ultraviolet patterning (VUV) and significantly impacts both the shape and size of Marangoni flows over film surfaces.

Gold NP films comprised of isolated NPs roughly 450 Å thick were fabricated by dynamic oblique deposition on glass substrates. Two separate SAMs were then applied in series. The first, derived from hexadecanethiol, assembled on the gold NPs themselves and the second, derived from octadecyltrimethoxysilane, assembled on the glass substrate exposed between NPs. As fabricated both SAMs are akyl terminated and thus hydrophobic. Samples were then subjected to VUV for varying lengths of time. VUV oxidizes akyl termination, imparting more hydrophilic character. Water contact angle, shown in Figure 1, can thus be varied controllably. On inducement of Marangoni flow several trends emerge, including in changes in flow shape, visualized in Figure 1 with 75 µm diameter polystyrene beads, as well as flow size and bead accumulation, as shown in Figure 2. Work is presented in the context of designing microfluidic devices driven by Marangoni flows.

Figure 1: Water contact angles and corresponding Marangoni flow patterns. Bubble diameters are all approximately 50 µm.

Figure 2: Bead density in Marangoni flow areas on surfaces of differing wettability.