Continuous inline metrology of roll-to-roll micro-contact print process

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Abstracts:

Roll-to-roll (R2R) print process holds the promise of nano-scale precision, meter-scale width, and meter-per-second speed. The main limit of the R2R process scale-up from lab to industrial manufacturing is the lack of inline metrology tools for the large area of tiny printed patterns on the continuously moving web. Regarding the micro-contact print (μCP) process on R2R, the super-thin printed patterns even make the pattern invisible in normal optical imaging systems.

To solve these metrology problems in quality monitoring and controlling of the R2R μCP process, we proposed a real-time imaging technique based on controlled condensation figures (CFs) and closed-loop feedback image registration. First, we designed a high-resolution optical surface inspection system based on open-environment droplet-size-controlled CFs (Figure 1). This is done by real-time imaging and recognizing the condensed droplet sizes and densities on surfaces, and accordingly tuning the vaporization and evaporation of droplets on the surface by the vapor flow rate. Second, we developed a closed-loop feedback image registration algorithm for the consecutive and sequential images of continuous printed patterns. The algorithm leverages the temporal and spatial relationships of the consecutive images for fast, accurate, and robust point matching. This algorithm avoids the failures that conventional image registration algorithms would have when being applied to the R2R print pattern images containing duplicate and deformable patterns in the manufacturing process

Our experimental results showed that the proposed imaging metrology method can achieve high-precision pattern metrology for a continuous R2R print process. Our future work is the integration of this metrology system in the online R2R μCP in-process control.

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Reference:

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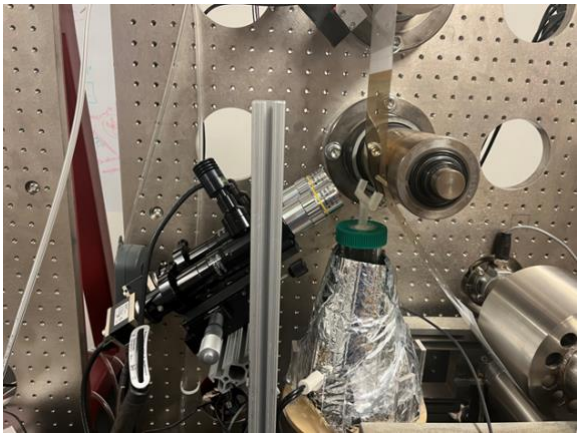

Figure 1. Experimental setup for imaging condensation.

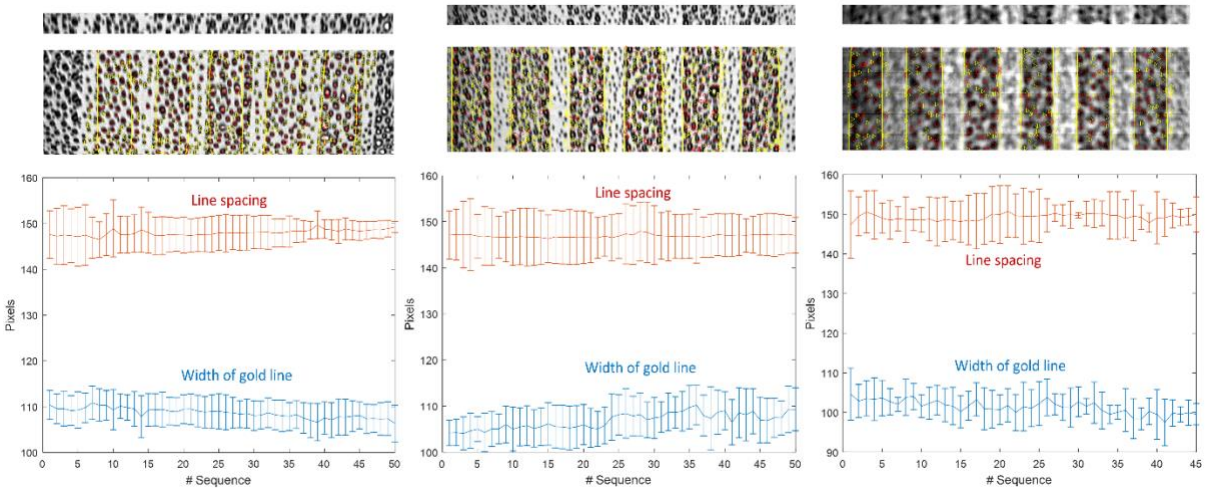

Figure 2: Metrology of print pattern with clustering results for various web-moving speeds: (a) 0.3 In/s; (b) 1.5 in/s; (c) 3 in/s. Row 1 – single frame; row 2 – line pattern (yellow contour) recognized from droplet clustering (circle for larger droplet and triangle for small droplet) of stitched images; row 3 – average width and standard deviation of the hydrophilic pattern (gold) and pitch of print lines.