Process Upscaling – Nanoimprint from small to large areas

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Nanoimprint technology and processes have shown tremendous success over the last couple of years in realizing smaller and higher aspect-ratio structures for various applications. Logically huge markets as photovoltaics, lighting and life-sciences have been keeping a close eye onto the technological possibilities nanoimprint technology is able to provide. Now the scale-up from small laboratory sized processes and machinery into production-ready scalable ones is the crucial step for nanoimprint to develop from a niche to a mainstream production technology.

This step has been taken by Coatema together with German UV-NIL specialist Temicon with the development of a highly advanced set of UV nanoimprint lithography lab and production technology. Scales of up to 1.1 m that have not been possible before have been reached through the combination of a robust scalable process and innovative approached to applied process technology and machine design.

The authors present the dedicated research and lessons learned for the development and upscaling of a highly versatile and high-throughput roll-to-roll manufacturing line for especially seamless low-temperature nanoimprint applications. Various methods have been applied to overcome bottlenecks throughout the whole scale-up process.

An overview on state of the art fast (10m/min) and seamless R2R UV-Nanoimprint lithography with an aspect ratio of 0.5 and a width of 300mm (see Figure 1) for an overall production of 3m²/min will be given as an intermediary step to mass production. The feature size of the reproduced structures ranges from several mm to tens of µm down to 380 nm.

Furthermore, the latest developments in manufacturing technology and R&D, advancements and drawbacks in large area roll-to-roll seamless UV and thermal nanoimprint lithography will be presented. Such micro- and nano-patterns confer polymer surfaces with light-guiding, light-trapping, light-diffusing or microlens effects and have enhanced OPV and OLED efficiencies quite significantly.

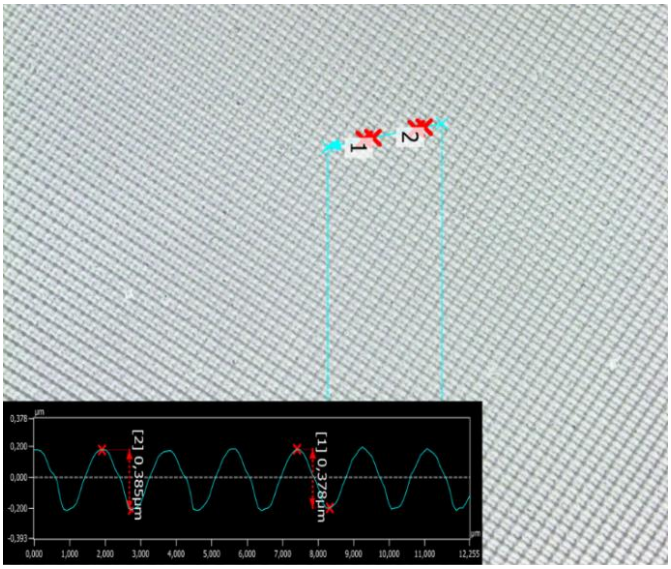

Figure 1. Confocal laser image of large area and fast processed UV-NIL nanostructures (380 nm depth and 760 nm period @ 3 m²/min)

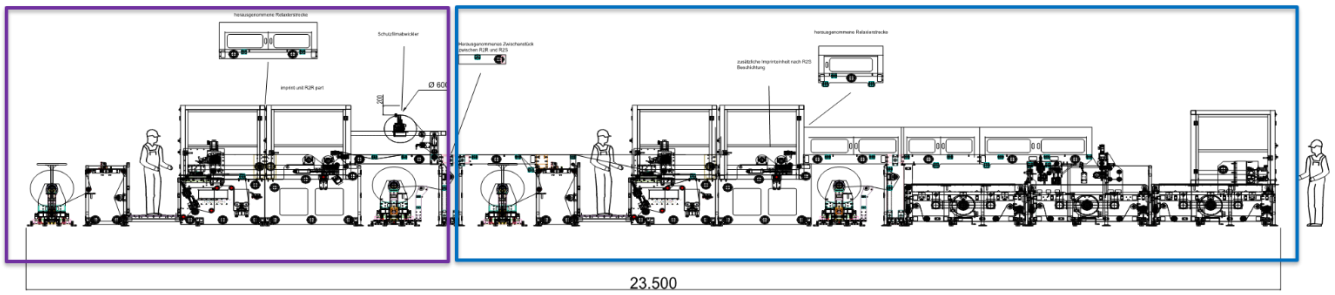

Figure 2. Schematics of a combined 23.5 m long roll-to-roll (violet) and roll-to-plate (blue) UV-Nanoimprint machine with a working width of 1.1 m.

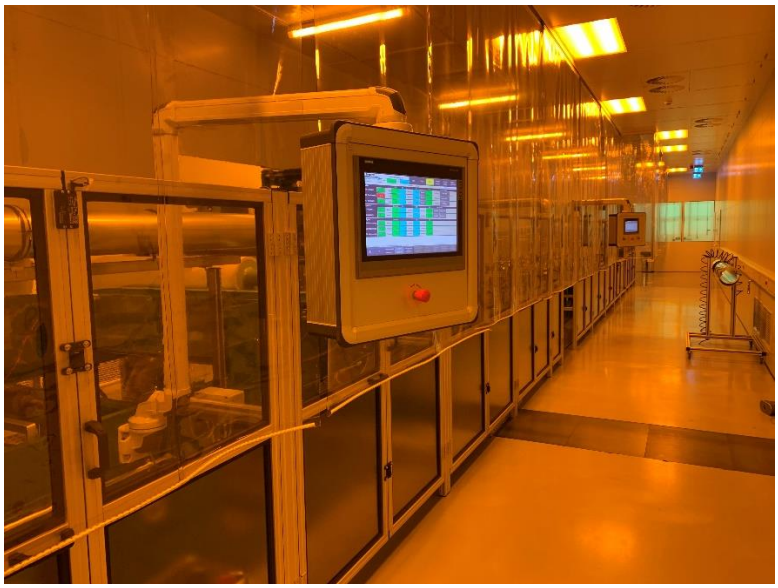

Figure 3. Picture of the above shown machine installed in the Cleanroom at Temicon.