From lab to fab - Roll to Roll replication of microstructures in to PDMS

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Polydimethyl siloxane (PDMS) has been already two decades extremely important material for prototyping microfluidics for biomedical research. [1] Still recently, related mass production of PDMS devices has been considered difficult and for example roll processing even impossible.[1]
Very recently, we have developed Roll-to-Roll replication process and demonstrated functionality of such microfluidic components by performing nucleic acid amplification in roll-to roll replicated device. [2] The molds for replication process were in house made photoresist master molds attached on hot embossing cylinder. We have found photoresist molds to be sufficient for prototyping purpose. For production, durable metal molds can be used. In replication we used two component room temperature vulcanizing silicone elastomer (Wacker Elastosil RT604) and aluminized paper substrate (Zanders Chromolux).[2] Web speed in replication was 1,5 m min^{-1} which equals 9 m^2 h^{-1} with 100 mm wide web. With standard microscope slide sized devices (25 mm × 75 mm) total area equals 4800 devices in an hour. The same machine is also capable to operate with 200 mm wide web, which doubles the throughput.

We have also demonstrated rotary screen printed silver conductor traces on PDMS substrates, which enables combination of PDMS microfluidics with many electrical functions. Electrochemical sensors are commonly used in diagnostics. [3] Conductive traces are many times essential for signal and power transportation for other sensor devices. We used commercial silver paste (from Creative Materials) and substrates (Elastosil film ™, from Wacker Chemie).

Microfluidics market size was eastimated for US$ 10 billion for 2018 and subject to reach US$28billion by 2023.[4] We believe there is constantly increasing number of highly potential PDMS based microfluidic applications developed in academy whose developers are looking opportunities to also develop business from their research. One option is to transform and redevelop the device physics and chemistries to meet existing mass manufacturing techniques such as injection molding. Another approach is to upscale manufacturing of existing prototypes. Our approach is to develop upscaled manufacturing process for microstructures and for that we using roll to roll techniques. VTT operates open access research infra structure for printed electronics, including two roll to roll pilot level machines equipped with embossing/imprinting units capable also on PDMS processing.

VTT leads Printocent community which is based on 3 research partners, city of Oulu and over 30 industry cluster partners. Purpose of Printocent is gather whole value chain and ecosystem together and boost industrialization and commercialization of printed electronics.

References:

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[3] Banks C.E., Killard T., and Venton B. J., "Introduction to electrochemistry for health applications", Anal. Methods, 2019, 11, 2736-2737
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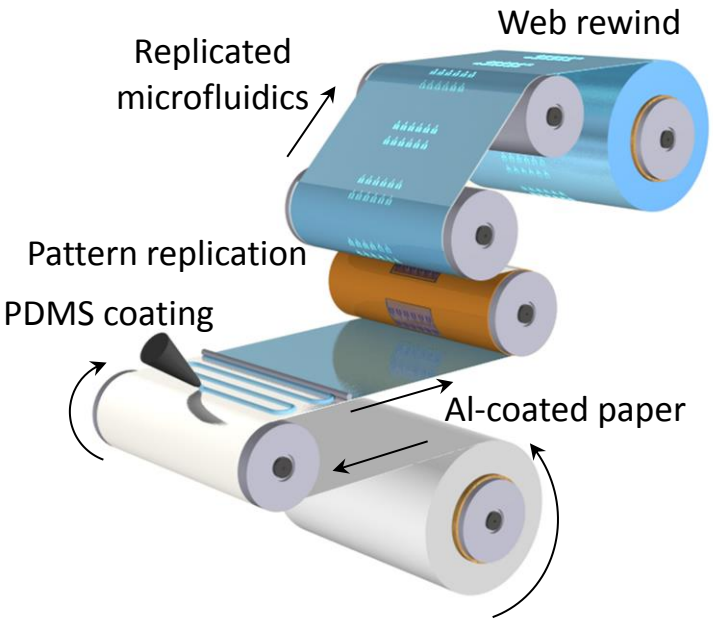

Figure 1 Roll to roll replication of PDMS [2]

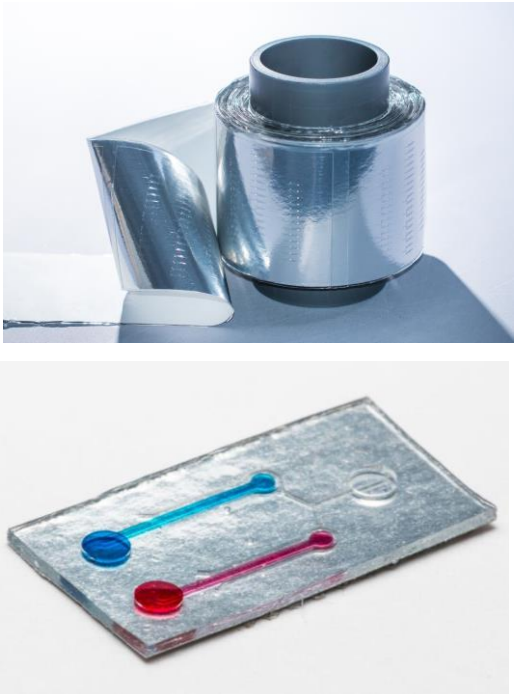

Figure 2 a) Roll of replicated PDMS fluidics on aluminized paper in width of 100mm.
b) RNA amplification device filled with blue and red color [2]