Liquid metal electrical conductors in R2R imprinted PDMS microfluidic channels

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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]

PDMS microfluidics can be utilized in elastic electronics by applying conductive liquids, like liquid metals in microfluidic channels [3]. We demonstrated R2R replication of microfluidic channels in PDMS by using Momentive RTV-615 2-component silicone elastomer on Melinex ST506 PET substrate (Figure 1). We used etched metal master shim welded to a sleeve which was then installed on hot embossing cylinder. We deposited pre-mixed silicone elastomer manually and levelled it with spiral bar (nominal wet thickness of 300µm) following the R2R imprint step on roll mold with surface temperature of 165℃. Process sequence was as presented by Hiltunen et al 2018 [2]. Web width was 200mm and web speed was 2 m/min which equals throughput of 24 m^2/h. We lidded channels with blank cured film of same RTV-615 PDMS using manual vacuum plasma bonding (Technics Plasma GmbH Tepla 440-G, O_2, 300W, 1min) channels with Eutectic Gallium – Indium alloy (eGaiIn) by using vacuum suction. We measured electromechanical performance of this liquid metal conductor by applying 50% strain and repeated strain 10 and 100 times. (**Figures 3 and 4**) We did not observe significant hysteresis but resistance recovered perfectly. Either we did not observe in performance with different velocity of the stretching.

Microfluidics market size was estimated 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] Shi Cheng (September 12th 2012). Elastomeric Electronics: A Microfluidic Approach, Advanced Elastomers - Technology, Properties and Applications, IntechOpen,
[4]https://www.marketsandmarkets.com/Market-Reports/microfluidics-market-1305.html

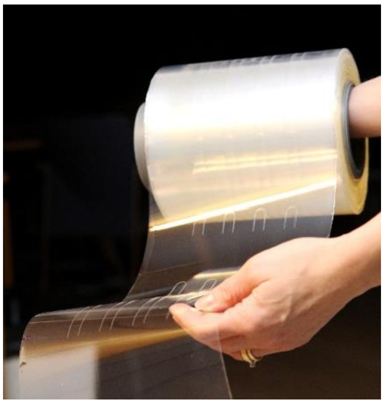

Figure 1 Roll of R2R imprinted µfluidic channels in PDMS. Web width 200mm.

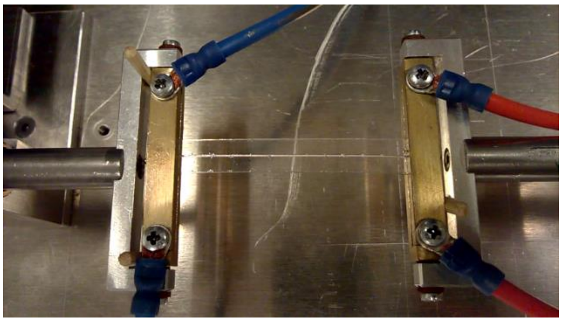

Figure 2 Resistance measurement in cycled 50% strain

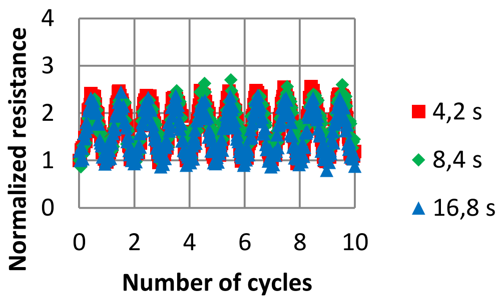

Figure 3 Ten cycles 50% strain resistance measurement with three different cycle times

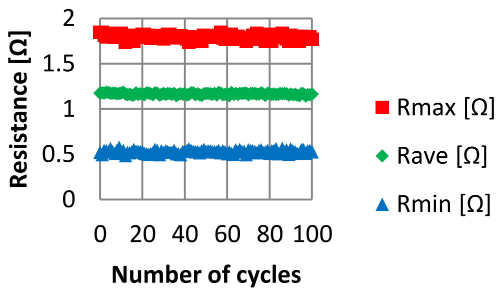

Figure 4 Hundred cycles 50% strain resistance measurement with 4,2s cycle time