Replication of undercut trenches for water based lift-off process by residue-free UV-NIL

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Low cost lift-off processes are favored in polymer electronic to realize metallic structures without etching. Lift-off requires recessed resist structures, which are typically realized by multilayer resist systems including under etching on the substrate[1].

Herein we report on a time and cost saving nanoimprint process that uses an elastomeric stamp to replicate undercut trenches for a lift-off process in a single layer resist. Although recent results have shown that undercut features can be replicated by nanoimprint[2] a complete etch free solution was not available.

In our new nanoimprint process the formation of recesses is integrated in the template fabrication and combined with a residual free imprint to avoid plasma etch steps on the final substrate completely. The process flow is depicted in figure 1. From a silicon masters with undercut features produced by reactive ion etching PDMS stamps were replicated by cast molding. Residual free imprint in ACMO resist was achievable due to complete dewetting properties of the resist on the stamp and substrate surfaces. Subsequent UV-Curing was used to harden the resist conserving the undercut features. The T-shaped PDMS stamp was separated leaving a recessed lift-off mask on the substrate. The demolding was possible due to the elastomeric nature of PDMS allowing a large damage free deformation. Zero residual layer conditions accomplished allows the direct deposition of metal layer without any break-up or descum etch step. In addition the ACMO resist is water soluble after solidification, allowing an environmental friendly lift off[3]. SEM images of the resulting features are shown in figure 2.

This concept of zero residual layer imprint with undercut opens up new exciting possibilities for mass production e.g. in polymer electronics either using imprint or roll to roll. We will discuss potentials and limits of this process solution.

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[1] Ken-ichiro Nakamatsu, K. Tone, S. Matsui "Nanoimprint and Lift-off Process Using Poly(vinyl alcohol)", the Japanese Journal of Applied Physics, Vol.44, No.11, 2005

[2] S.Möllenbeck, N. Bogdanski, M. Wissen, H. Scheer, J. Zajadacz and K. Zimmer, "Multiple replication of three dimensional structures with undercut", American Vacuum Society, J.Vac.Sci.Technol. B 25(1), Jan/Feb 2007, S.247-251

[3] C. Auner, B. Stadlober, H. Gold, J. Kraxner, "Residue-free room temperature UV-Nanoimprint of submicron organic thin film transistors", organic electronics 10 (2009), S.1466 – 1472.

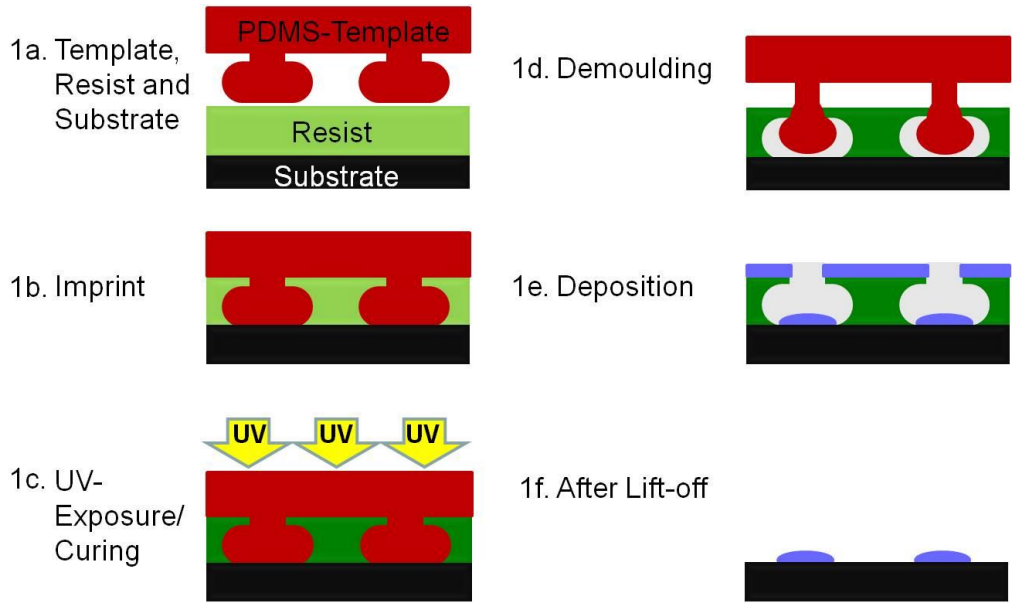

Figure 1: Process scheme, 1a) Template with mushroom like features; b) Imprint into liquid resist; c) Resist curing via UV-exposure; d) Template deformation during detachment; e) metal deposition; f) Metal pattern after resist lift-off

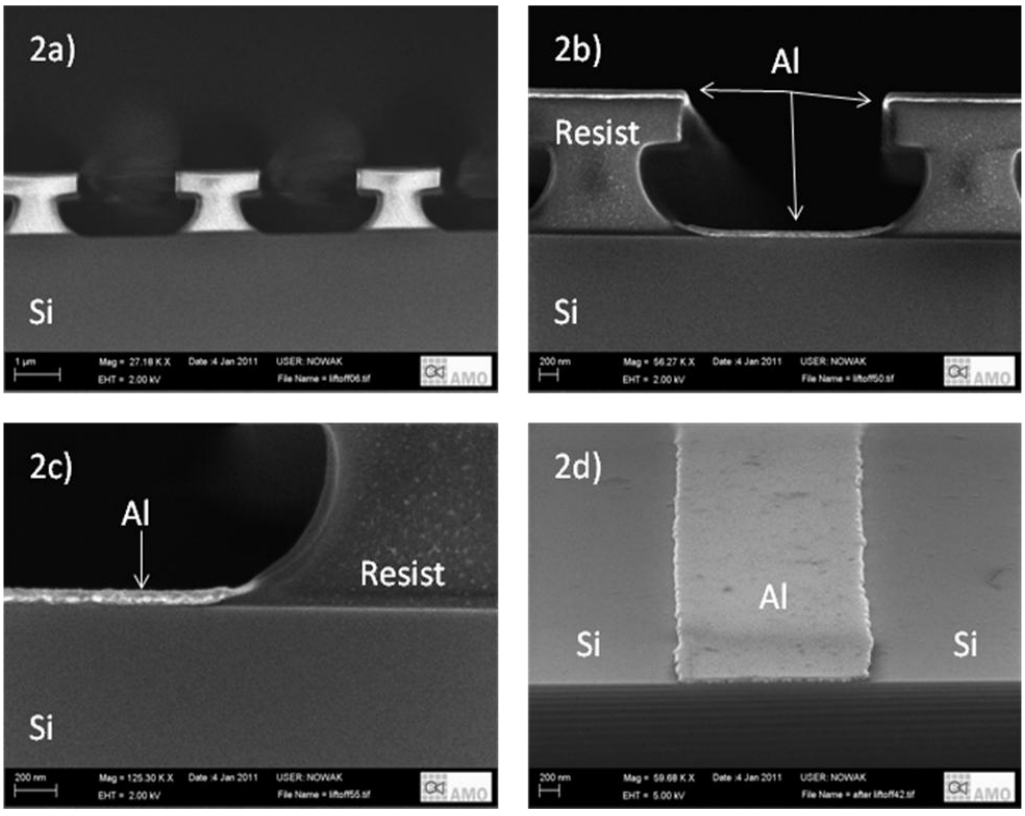

Figure 2: Figure 2 : T-shaped resist structures after imprint; b) Pattern after metal deposition; c) Close-up of metal cut off region; d) Final metal layer after lift-off