Microneedle Array Fabrication based on Thermomigration

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This paper introduces a method to manufacture microneedle arrays, using a combination of low-cost microfabrication techniques namely, thermomigration, wet-etching KOH solution and thin-film deposition. Typically, a microneedle design is characterized by a pyramidal shape with a through hole inside [1]. In order to accomplish such design, the proposed fabrication method starts with photolithography patterning a 150 µm thick silicon wafer's surface with an aluminum layer to create an array of hollow squares (figure 1a). On the wafer's backside, a protective silicon nitride thin-film 1 µm thick is deposited with the holes pattern.
As the wafer undergoes a strong thermal gradient, it triggers the thermomigration process [2]. The aluminium squares form droplets of a silicon-aluminum eutectic mixture, which migrate along the temperature gradient towards the hotter side. As the eutectic droplets move across the wafer's thickness, the silicon, now doped to saturation with aluminum, recrystallizes behind the droplets, leaving a trail of p+ type silicon in the n-type wafer (figure 1b), [3].
The existence of different doped regions through the wafer's cross section enables a selective KOH etching [4], as the n-doped region is etched faster than the p-doped region (an etching rate 28:1) [5]. As soon as the wafer is submersed on a 30 % KOH solution, etching process starts, finally creating pyramidal shapes with through holes in the middle (figure 1c). A combination of two basic and cost-effective techniques, namely, thermomigration and wet-etching KOH solution, allows to fabricate 150 µm microneedles long with a potential use in drug delivery for neural applications [6].

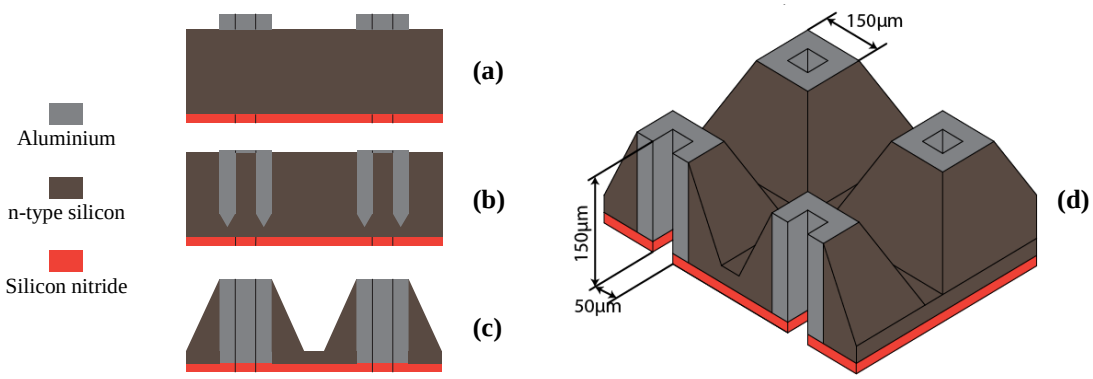

Figure 1 – Proposed microneedle fabrication method: a) Aluminum deposition; b) Thermomigration phenomena; c) KOH Etching d) Tridimensional representation of the final structure.

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