High quality ion channels recordings on an injection molded polymer chip - DTU Orbit

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In this thesis we demonstrate high quality recordings of the ion channel activity across the cell membrane in a biological cell by employing the so called patch clamping technique on an injection molded polymer microfluidic device. Such recordings are traditionally made using glass micropipettes, or in recent years using consumable microfluidic chips of high costs. The patch clamping method is widely used both in fundamental studies of electrophysiology of living cells and tissue and in drug discovery.

The findings of this work will allow direct recordings of ion channel activity to be made using the cheapest materials and production platform to date, and with the potential for very high throughput. The employment of cornered apertures for cell capture allowed the fabrication of devices without through holes via a process comprising master origination by dry etching in a silicon substrate, electroplating in nickel, and injection molding of the final part. A thorough characterization of the patching orifices by means of SEM and AFM showed high replication accuracy through the fabrication process.

The most critical device parameters were identified as the length of the patching capillaries and the very low surface roughness inside of the capillaries. The cross-sectional shape of the cornered apertures was found to be less critical, as apertures with different profiles were tested with cells and showed the same ability to form tight seals with cells with negligible leak currents. The ability to form high resistance seals in the GOhm range, the so called gigaseals, is demonstrated with a success rate of 15%. The devices were functionally tested with Human Embryonic Kidney (HEK) cells expressing voltage-gated sodium channels and benchmarked against a commercial state-of-the-art system for automated ion channel recordings. These experiments considered current-voltage relationships for activation and inactivation of the sodium channels and their sensitivity to a local anesthetic, lidocaine. Both IVs and lidocaine does response curves obtained from the injection molded polymer device were in excellent agreement with data obtained from the commercial system.

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