Biocompatible Lithium Niobate for Sensing and Microfluidics Applications

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Lithium niobate (LN), with its large nonlinear optical coefficients and reversible spontaneous polarization, is widely used in optoelectronic and photonic applications and has recently been used in micro- and optofluidic applications, which take advantage also of the piezoelectric, pyroelectric or photovoltaic properties of the crystals.[1–3] Not only can the surface charge and reactivity be patterned via polarization reversal but LN can be chemically and topographically patterned by proton exchange and etching, respectively. Furthermore, LN has been shown to be cytocompatible with MC3T3 osteoblast cells, providing opportunities to use LN in biological applications.[4,5] Here, we lay the groundwork for two such applications: cell sensing and microfluidic devices with combined chemical and physical cues. Photodeposition of silver nanoparticles onto chemically patterned LN having alternating LN and proton exchanged regions has been previously investigated.[6] Here, we demonstrate the spatially defined photodeposition of gold nanoparticles onto periodically proton exchanged LN.[5] The cytocompatibility of photodeposited gold, silver, and bimetallic ferroelectric templates to MC3T3 cells was investigated. Gold samples provided significantly greater cell biocompatibility (Figure 1),[5] suggesting opportunities for surface enhanced Raman-based cell sensing. We also explored the suitability of LN as a novel neural substrate and investigated the influence of reactive ion etching-induced topography of LN surfaces on neurite guidance. On submicron-deep trenches, neurites aligned with the edges of the topographical features. Finally, we bonded a bicompartmental microfluidic chip to LN surfaces patterned by etching to create isolated axon microenvironments with predefined topographical cues (Figure 2). Thus, LN is shown to be a novel neuron culture substrate with tunable electrical and topographical properties that can be integrated with microfluidic devices suitable for studying axon growth and guidance mechanisms under combined topographical/chemical stimuli. Such in vitro devices that combine chemotactic and physical cues can be used to understand how neurons integrate different stimuli.

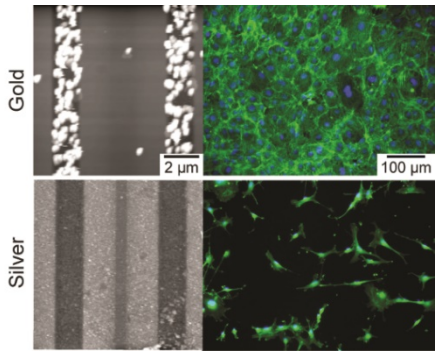

Figure 1. Gold nanoparticle arrays on LN surfaces provided significantly greater cell biocompatibility compared to silver.

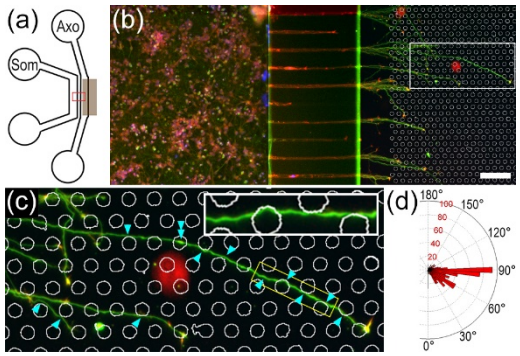

Figure 2. Bicompartmental microfluidic chip bonded to LN to create isolated axon microenvironments with predefined topographical cues. Scale bar = 100 µm.

References

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