Nanoimprinted Electrodes for Highly Efficient and Stable Bio-Fuel Cells

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Nanoimprint lithography (NIL) is regarded as next generation lithography capable of high resolution and high throughput. One of promising applications of NIL is direct patterning of nanometer structures in plastic materials. Recently, we have shown fabrication and characterization of metal wire-grid polarizer on a flexible plastic substrate [1]. In the current work we demonstrate the use of NIL to make highly efficient, stable and flexible electrodes for bio-fuel cells (BFCs), fuel cell utilizing biocatalysts for chemical energy transformation into electrical energy via heterogeneous redox reactions. Small BFCs have a potential as electrical power supply for self-contained implantable electronic devices [2].
In this study the flexible electrodes for the BFCs were fabricated using sheets of plastic, used typically in Intermediate Polymer Stamp process (IPS, licensed from Obducat Technology AB). For imprint we used Ni stamp with regular features of ~100 nm in size, made by interference lithography. The NIL process was performed at T=160°C, pressure of 50 bar and time of 120 s. After demolding, the polymer sheet was modified with the regular nanometer features, Figure 1. The surface of the polymer sheets were covered by 100 nm thick Au layer with 5 nm Ti sub-layer. The final electrodes were cut from the sheets to make 10x10 mm^2 electrodes for BFCs and biomodified with bilirubin oxidase (BOx). For reference purposes, unpatterned plastic sheet were treated in the same way as the patterned ones. Well-pronounced bioelectrocatalytic reduction of O_2 was obtained. The nanostructured polymer surface provided ~4 times increase in bioelectrocatalytic current density and ~10 times increase in operation stability, Figure 2. *Acknowledgements* This work was supported by the Swedish Research Council (project No. 621-2009-3266), Linnaeus grant (No. 60012701), the European Commission (project No. FP7-NMP-2008-229255), and The Knut and Alice Wallenberg Foundation (project No. KAW 2004.0119).

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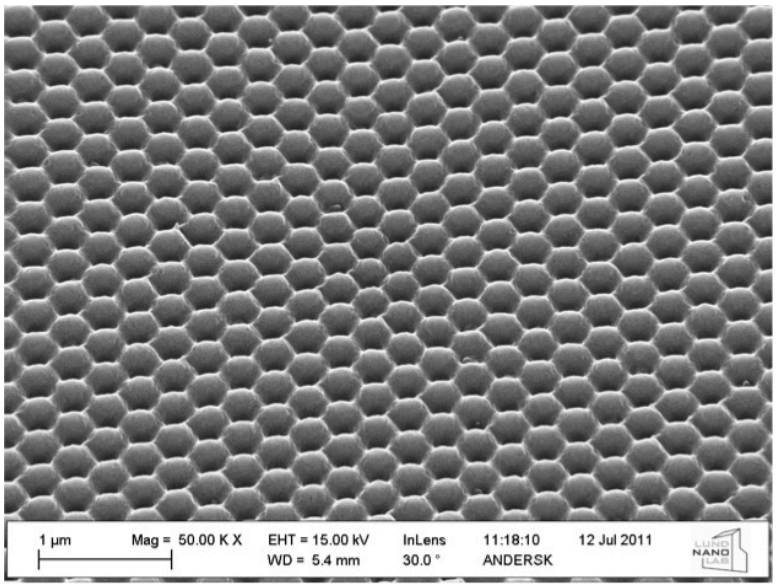

Figure 1: Scanning electron micrograph of the patterned polymer sheet after nanoimprint and metallization. The size of the imprinted features is ~100 nm. The imprinted surfaces were used as flexible nanostructured electrodes for biofuel cell application.

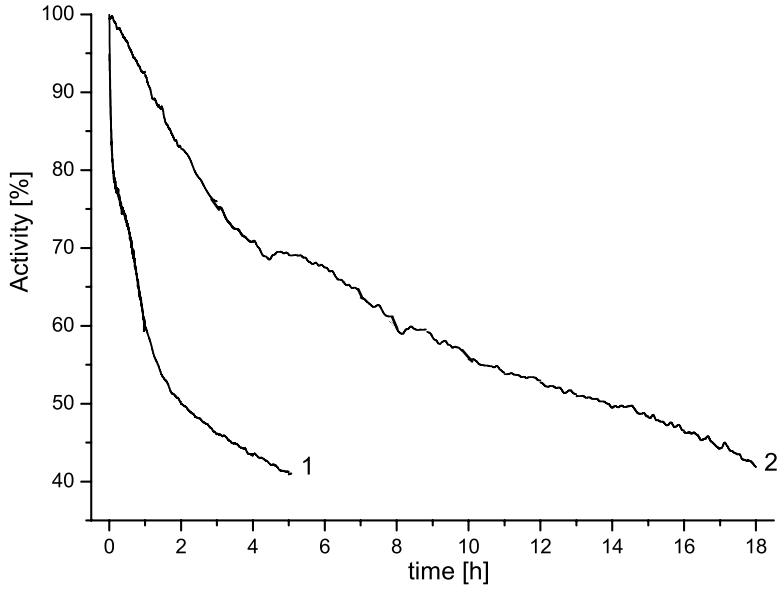

Figure 2: Life-time of bilirubin oxidase modified Au electrodes with reference electrode (1) and the nanoimprint-patterned electrode (2). About 10 times increase (for 50% performance reduction) in operation stability of biodevices was observed after NIL patterning of the electrodes.