Large area electrodeposition of scattered nanowires microlithographically interconnected for electrical components

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We demonstrate the ability and prospects of combining the nanowire electrodeposition technique with microsystem technologies (MST). The nickel and copper depositions are done ion track filter templates composed of nanopores. We present a method to build passive microelectronic components such as electrical resistors, capacitors, inductive micro-coils, as well as vias for z-conduction. We use a substrate compatible and appropriate for microelectronic integration. The parameters of the electrodeposition process are interrelated to properties of the structure and completed component: wire morphology, area uniformity, and contact resistance between wires and metal pattern.

To make the membrane filters i.e. the templates, the polyimide (PI) foil is irradiated with swift and heavy ions. The generated *ion tracks* are composed of narrow trails of damaged material [1] scattered stochastically over the surface. These ion tracks are translated into nanopores with high aspect ratios ($\geq 10^3$) using an appropriate etchant. The pores are then used as templates for the electrodeposition of various metals [1, 2]. The three principal types of coupling that can be established to the front contact are illustrated in Fig 1. The electrodeposition current for a typical sample, Fig.2, can then be interpreted. We demonstrated that it is indeed possible to interconnect these high aspect ratio nanostructures, Fig 3, with contact patterns of thin gold with high lateral resolution (1-5 µm). Double-sided photolithography is used, Fig. 4. Considering statistics we have found that the statistical deviations in electrical resistance per contact can be mastered if the number of wires/contact is at least 10. So, using, say, in average 50 wires per contact makes it possible to combine hundreds (or more) of these structural elements (wires+gold patterns) to produce a specific response in a component; i.e. multiple structural elements arranged in array patterns, e.g. in a series or parallel fashion. If one instead deposit a magnetoresistive material the component could be used as a magnetic field sensor where the electrical resistance would depend on the applied magnetic field.

ILLUSTRATIONS AND GRAPHS

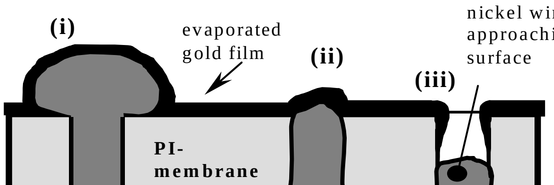

Fig. 1. The three primary types of coupling to the evaporated front contact film.

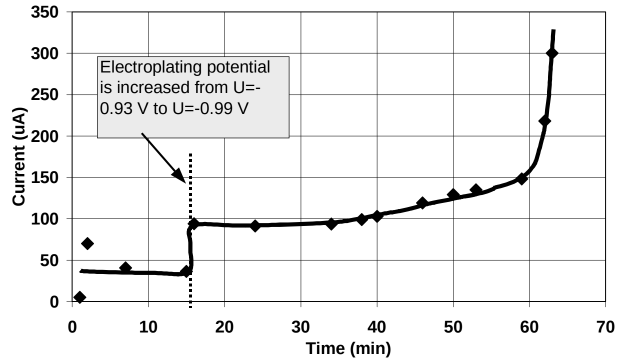

Fig 2. The typical current for electrodeposition of 500 nm wide nickel-wires. Note, that the current increases when the wires reaches the top surface of the foil.

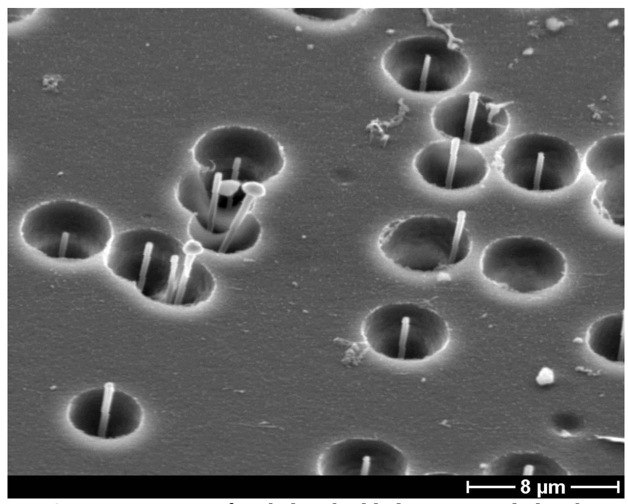

Fig. 3. Nanowires of nickel embedded in PI revealed etching the top layer of the membrane in an oxygen plasma.

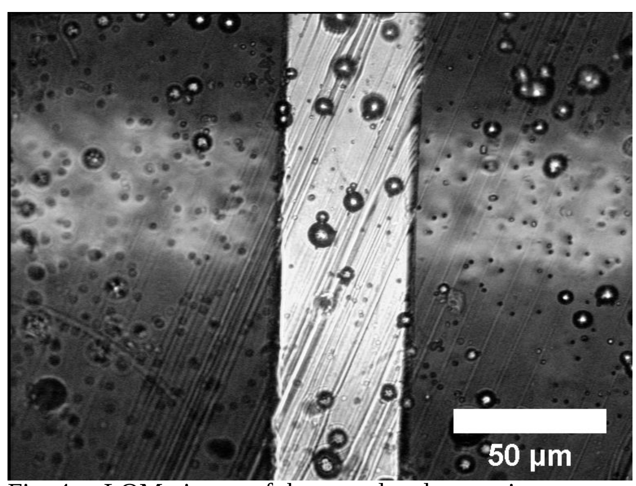

Fig. 4. LOM picture of the completed nanowire structure, including nanowires, pointing in the direction into the picture! The semitransparent membrane allows us to see both the front and the back gold contacts.

REFERENCES'

[1] R. Spohr, Vieweg&Sohn Verlag, 1990
[2] D. Dobrev et al, Nucl. Instr. and Met. in Phys. B. 149, (1999)

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