A Three dimensional e-beam lithography technique for the construction of high density micro and nanocoils

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Abstract

With the of reduction of the size in electromechanical systems in order to access particular frequencies or noise limits, the needs for new efficient methods for miniaturization of circuit electronic components is of critical importance. Researchers have invested much effort in the development of micro and nanocoils [1, 2]. In the literature there are basically two kinds of micro coils: 3D solenoidal coils with rectangular and circular cross section, and planar spiral coils. The former is the easiest way to build an inductor at the macroscopic scale and is also the more efficient configuration because of the uniformity of the magnetic field inside the coil and the high inductance. However when the scale is reduced, to the order of micro and nanometers, the difficulty for rolling a very thin wire around an axis increases considerably [3]. On the other hand, the planar geometry represents a very attractive way to construct micro and nanocoils because of the high compatibility with microfabrication techniques, although a cost is paid in the low uniformity of the inner magnetic field, and low inductance [3, 4].

In this work we present a procedure compatible with MEMS techniques for the fabrication of three dimensional micro and nanocoils. The technique used is based on the dependence, with dose, of the quantity of resist irradiated by the electron beam in the lithography (see Fig. 1), (3D lithography [5]). With this technique, we developed pyramidal structures with of 10 and 40 turns with a wire thickness from 5 to 1μm, and a distance between turns of approximately 100nm (See Fig. 2). The chosen shape of the coils increases the uniformity of the magnetic field within them as compared to the planar geometry, and also allows a greater density of turns, yielding an increased in the inductance. We will describe measurements of the coils inductance for several sizes of the wire, spacing between turns and minimum and maximum radii, comparing the experimental results with numerical simulations. These coils can be applied as magnetic field sensors [6] and in the development of electromagnetic actuators for energy harvesting applications [7].

References

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Figures

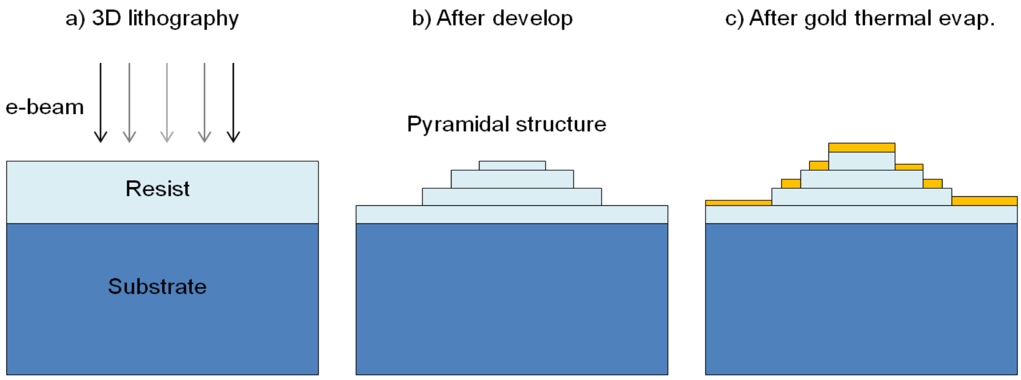

Figure 1: Diagram of the procedure followed to build 3D pyramidal coils. a) The first step consists of a dose varying electron beam lithography strategy. The gray scale in the arrows indicates different doses (from the smallest dose in gray until the highest in black). b) After developing, the resist will be removed in different amounts depending of the dose employed. c) Finally the conducting material (gold in our case) is deposited by thermal evaporation.

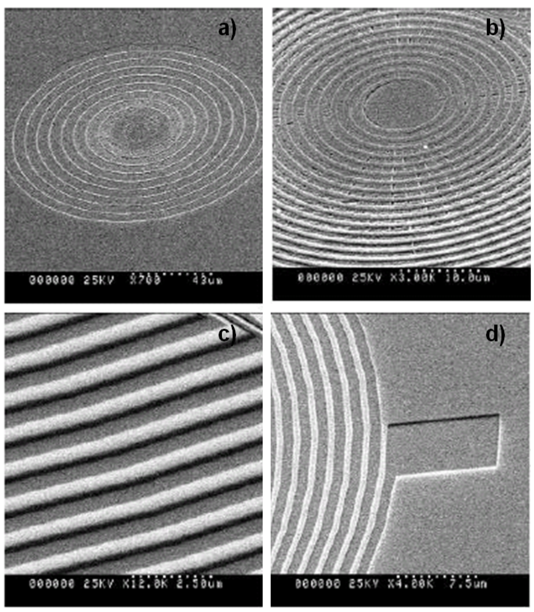

Figure 2: SEM images of the pyramidal structures fabricated with the technique described in this work. a) A ten turn pyramidal structure, with a wire thickness of 5μm and a separation between turns of approximately 100nm. b) A 40 turns pyramidal structure with a wire thickness of 1μm and a separation between turns of approximately 100nm. c) And d) close up images of the 40 turns structures and the external contact respectively.