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# Innovative direct-deposition of dielectrics – the solution for express processing?

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Electronic, optical and sensing devices with features in the sub-100 nm range are currently being tested. However, these nanodevices experience several challenges due to the reduced size, that may only be clarified by electronic testing. However, the high-costs and long processing time may delay or even restrict the exploitation of new types of nanosystems. Especially with 3-dimensional devices disproportionate process development is required before exploratory structures may be processed. This work introduces an innovative alternative to traditional processing by employing direct-write lithography with a focused beam. The potential for rapid fabrication of exploratory nanodevices and even 3-dimensional structures is demonstrated with functional elements.

The deposition of materials from a gas phase precursor was induced in a vacuum system utilizing the energy of a focused particle beam. The deposition of metals has already been successfully proven [1,2]. Silicon oxide was obtained with an organic silicon compound asdsorbed and decomposed on the sample surface. As the deposition is only triggered by the focused electron or ion beam, smallest depositions below 100 nm can be achieved. Hence, this non-traditional nanostructuring technique allows to add dielectric elements without the necessity of the usual lithographic patterning and etching of blanket layers.

Single dots and lines of deposited dielectric down below 90 nm were processed to demonstrate the potential for nanostructuring. But also larger structures in the µm range were processed where integration in microelectronic devices was an issue. The proposed direct-write deposition is fully compatible for integration with traditional semiconductor processing as it allows for combination with lithographic process steps. The control of the beam position facilitates alignment to markers on the sample as well as optical alignment by imaging with the focused beam. Examples of direct-write deposited interconnect structures were integrated in an existent microchip circuitry.

The deposition rates of the dielectric material were determined by thickness measurements with a scanning probe technique. Chemical analysis of deposited material was performed by Auger electron spectroscopy. Contaminations of carbon were observed. Materials deposited by a focused ion beam also displayed significant impurities of Ga implanted with the focused ion beam. The effects of supplemental oxygen addition and thermal annealing after deposition were investigated.
The results of this work demonstrate, that direct write deposition of dielectric material is feasible. This non-traditional approach for dielectric structure fabrication unites material deposition and patterning within a single process step. This versatile method renders a powerful addition to the existing, traditional techniques.

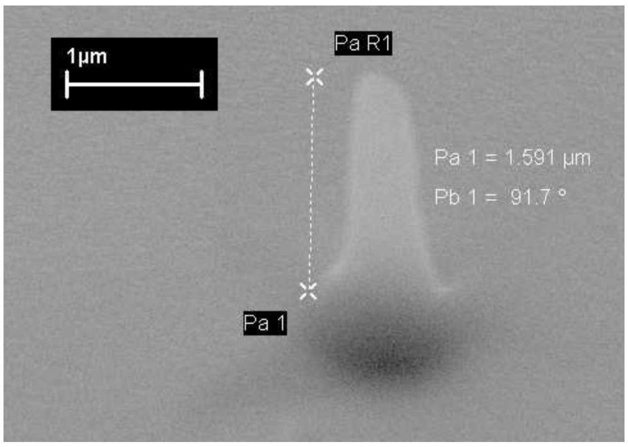

Fig. 1 Single large pillar of silicon oxide fabricated by focused electron beam deposition.

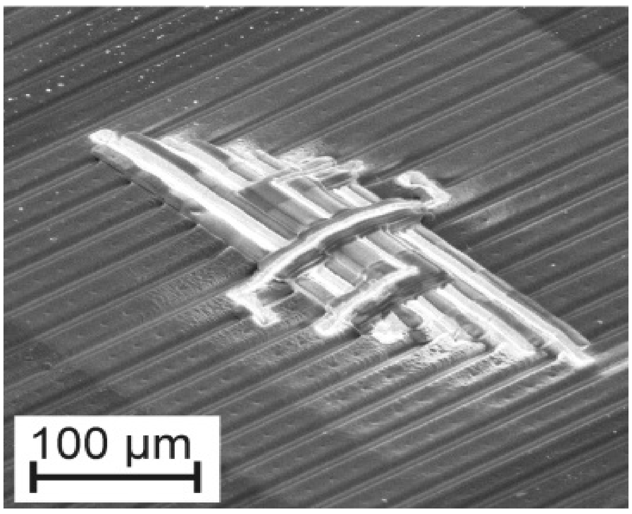

Fig. 2 Complex 3-layer interconnect structure integrated on a microelectronic circuit. 6 layers of dielectric and metal fabricated in alternating sequence utilizing focused ion beam induced deposition.

[1] A.J. DeMarco. J. Melngailis; J.Vac.Sci.Technol. B 19(6), 2543 (2001).
[2] H. Bruckl, J. Kretz, H.W. Koops, G. Reiss, J.Vac.Sci.Technol. B 17(4), 1350 (1999)
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