Fine and dense nanofabrication with Helium Ion Beam Induced Deposition

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50 words abstract

Ultimate resolution and pattern density in the fabrication of nanostructures with Helium Ion Beam Induced Deposition has been studied. The Pt deposits are inspected with Helium Ion Microscopy directly after deposition to quantify their geometry and the proximity effects. Electrical four-point measurements yielded line as well as contact resistance.

Abstract

Ion Beam Induced Deposition (IBID) is a direct writing technology in which precursor molecules adsorbed on a substrate surface are decomposed by an ion beam induced reaction, resulting in localized material deposition. Due to its high flexibility for the shape and location of the deposits, IBID holds much interest for prototyping three-dimensional (3D) nanostructures. Recently, the Helium Ion Microscope (HIM) with a sub-nm probe size has been developed and is now commercially available. For this contribution, IBID experiments were performed in a Carl Zeiss Orion™ Plus scanning HIM with a gas injection unit (OmniGIS™). $(CH_3)_3Pt(C_PCH_3)$ was used as precursor for Pt deposition.

This contribution discusses the resolution limit for isolated dots and lines as well as dense patterns. The experiments shown in Figure 1 and 2 reveal an excellent pattern fidelity and resolution. The relevant scale for proximity effects has been studied for different deposit geometries and aspect ratios, and is typically one order of magnitude smaller than for Ga^+ IBID. Figure 1 shows a dense Pt line pattern (pitch 50 nm, line width 15 nm, line height 20 nm) with a measured line edge roughness of 3 nm (3 σ). The similarity in shape and dimensions for the inner and outer lines proves the absence of proximity effects in this pattern. Electrical measurements are performed to determine contact resistance and deposit conductivity. The electrical properties of the deposited wires are related to the composition of deposited structures. Figure 2 illustrates the patterning of "large" area arbitrary shapes that have precise control over the dimensions on the nm scale: the gap between the capitals **T N O** is consistently 12-15 nm.

In conclusion, Helium Ion Beam Induced Deposition in the HIM offers a promising alternative technology for the precise Direct Writing of dense complex nanostructures. Typical applications that can be furthered with this technology are NEMS, Plasmonic devices, Photonic crystals, magnetic nano-domains and templates for protein crystal growth.

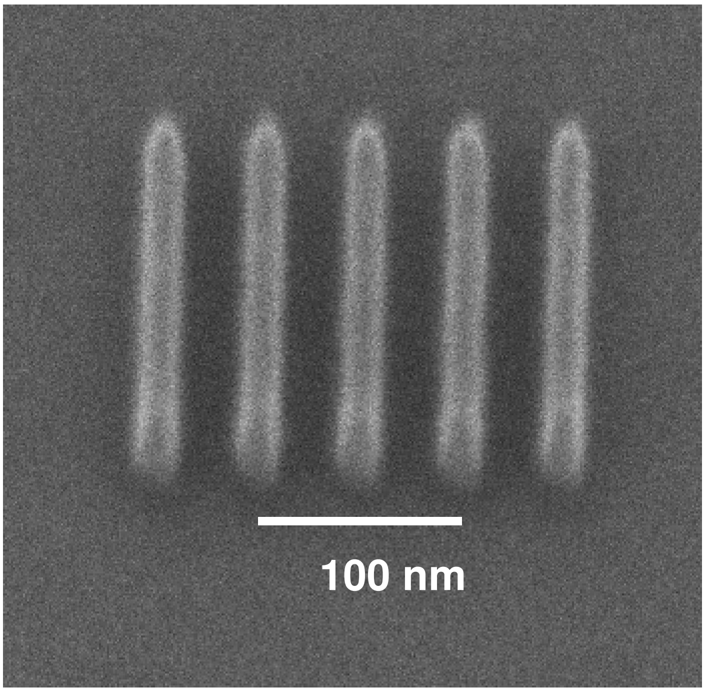

Fig. 1 Platinum lines (width 15 nm) at 50 nm pitch, deposited with HIBID and inspected with HIM at 30 degree tilt angle. Note that the outer lines are very similar to the inner lines, demonstrating very low proximity effects. The beam energy during deposition was 25 keV at 0.5 pA beam current.

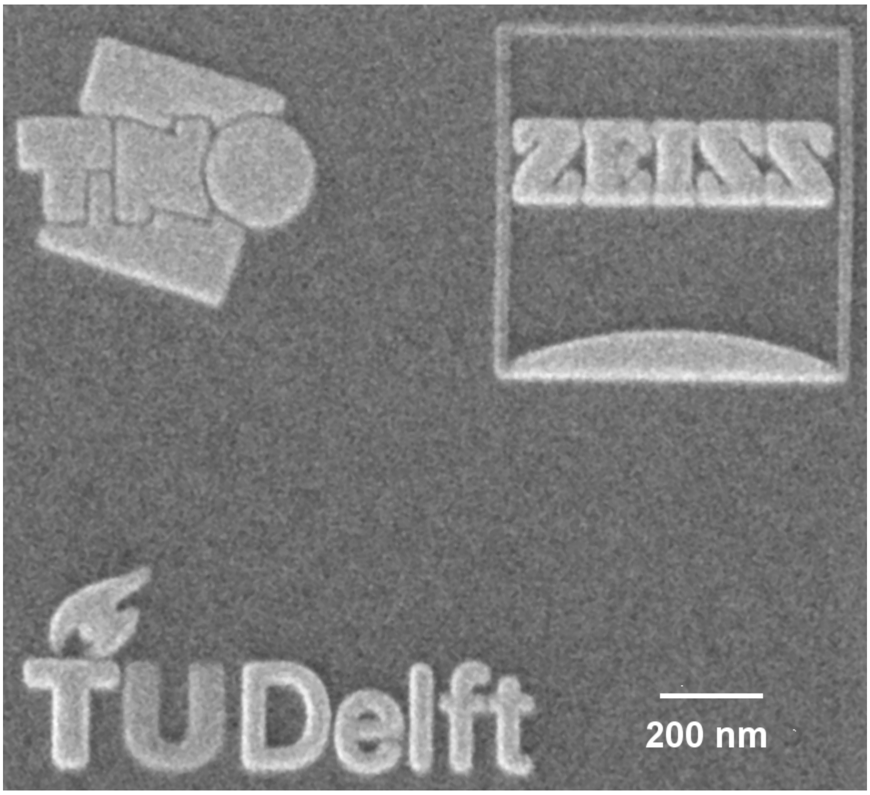

Fig. 2 Top-view HIM images of the TNO, TUD and Zeiss logo's made with Pt HIBID, demonstrating the ability to deposit "complex" dense patterns precisely. The gaps between the capitals T N O are approximately 12-15 nm, showing very low overspray. The beam energy during deposition was 25 keV, 0.5 pA beam current