Exploring the resolution limits of electron beam lithography (EBL) for isolated features, performed with converted scanning electron microscope Jeol JSM-7600F on PMMA resist

This short report shows some achievements obtained in attempts to decrease the linewidth of single lines produced with Electron Beam Lithography on the converted electron microscope Jeol JSM-7600F. In previous tests mostly dense arrays of lines were investigated where the narrowest lines had the width of approximately 450 nm with the 510nm pitch in between them. In some other test 100nm dots were noticed.

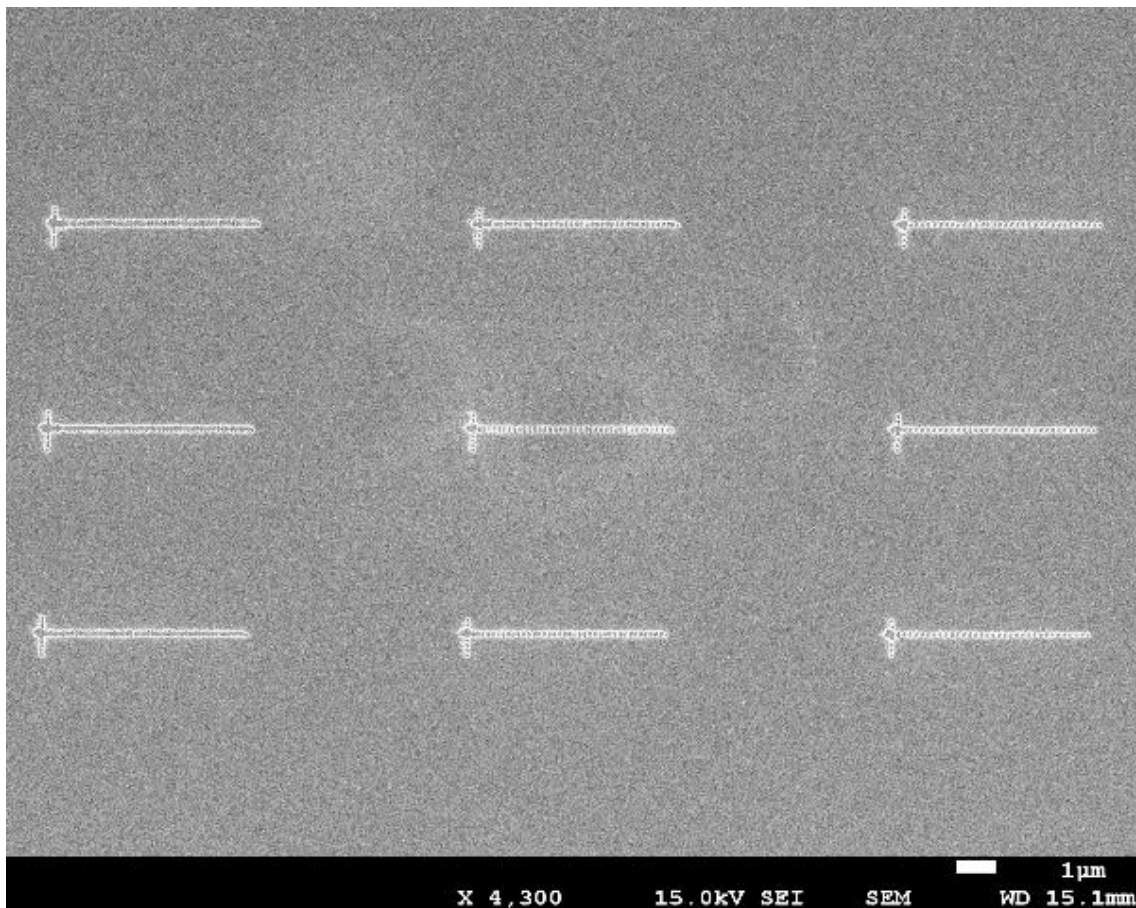

Figure 1. SEM image of the dots forming a line. The picture is taken before the lift off process. 9nm layer of Au/Pd is deposited on top of the developed PMMA resist.

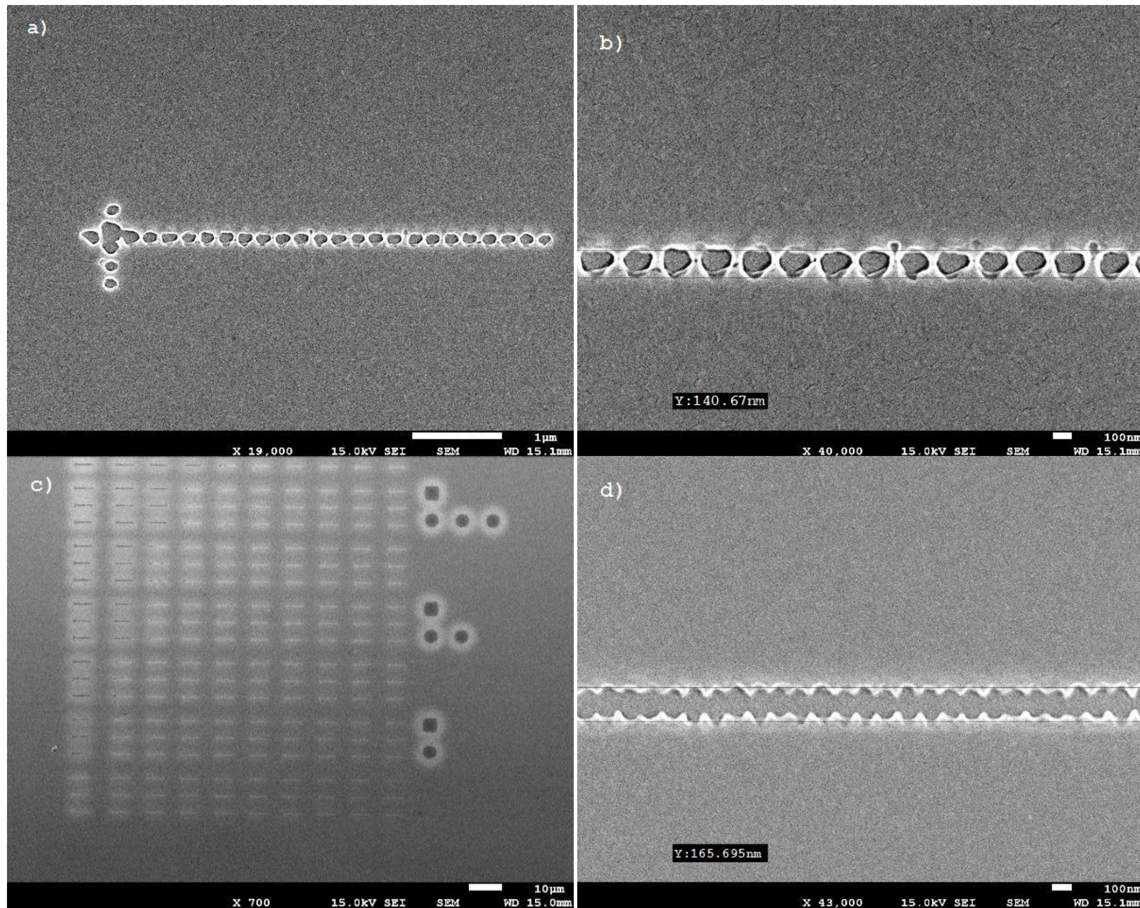

Figure 2: a),b)line of separated dots; c) the scheme of the test: lines appear on the left, the dose increases from the bottom to the top, the increment increases from left to right; d) connected dots

It was a natural idea to try to get very narrow single lines simply by bringing the dots closer. On the Fig. 1 the forming of a line by approaching of the dots is shown. On the right side of the Fig. 1 the dots are still separated. In the middle they are just touching each other whereas on the left they are already joined together and forms a solid (although very rough) line.

The width of the lines e.g. dots presented above is approximately 160nm. Even narrower lines and dots were found under different beam parameters and at shorter exposure times (Fig. 3) but the gradual transition from dots to lines there is somehow less obvious. The connected dots are wider than single ones due to the well known proximity effect.

The smallest dots found in these test measure about 80 nm in diameter and the finest lines have the linewidth of about 100 nm (Figure 3).

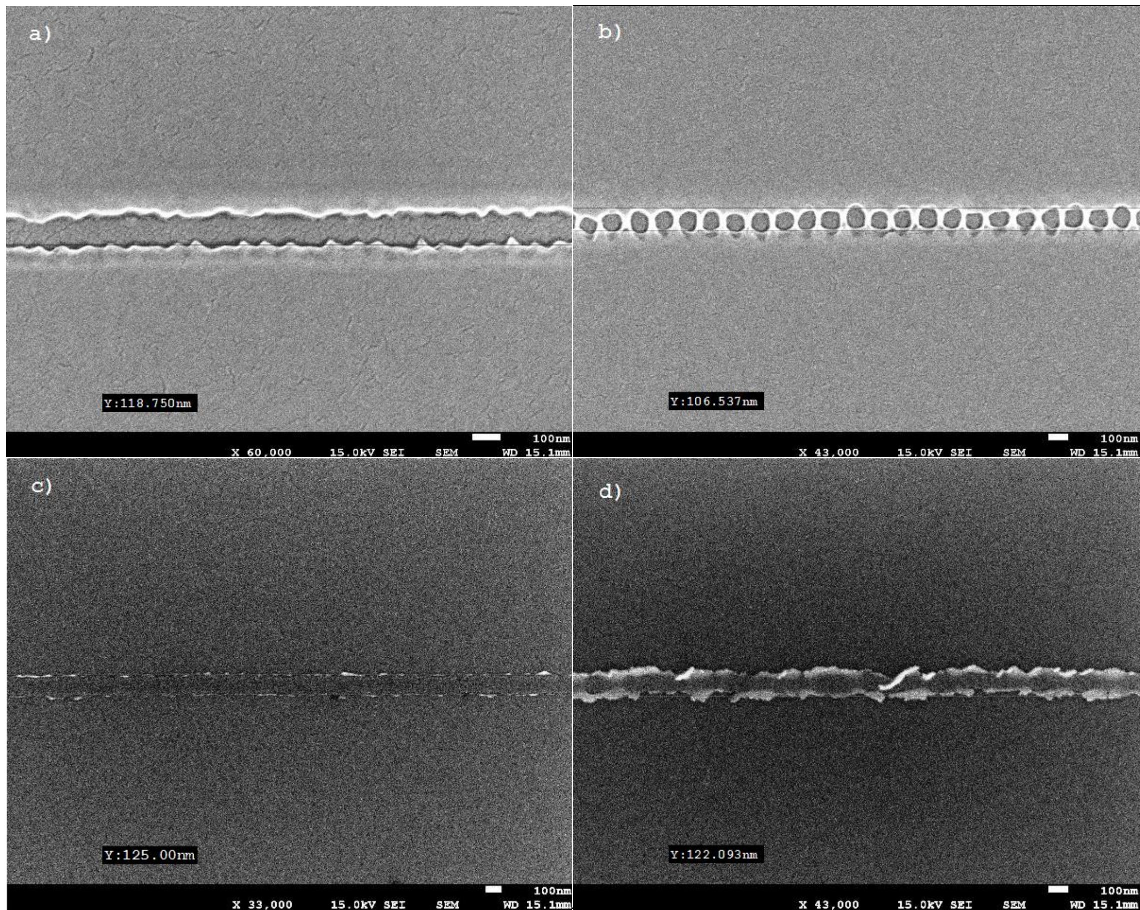

Figure 3:one of the narrowest lines found on the test; a) sample without lift off; c),d) sample with lift off performed

Two samples were investigated. One with the developed resist metallized, but not removed by lift-off and one with the lift-off performed. Surprisingly, the minimal linewidth on both samples is the same - 100 nm. Firm, solid lines, that emerges on the unfinished sample, clearly emerges on the finished sample too, after lift-off. The obvious thing is that the edges of the tyniest lines on the completed sample, after lift off, are very rough, undefined and so the linewidth is difficult to estimate. This is the consequence of the bad resist profile.