Ga^+ Focused Ion Beam Lithography as a Viable Alternative for Multiple Fin FinFET Prototyping

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This work presents the Ga^+ focused ion beam (FIB) lithography as a viable alternative for obtaining sub-100nm wide fins for FinFET prototypes with good repeatability and reduced processing time. Previous works have demonstrated 3D transistors fabricated using the Ga^+ FIB milling technique, which demands long processing times for fine fin definition and thus induces high doses of random Gallium incorporation on the transistor channel.[1,2] The Ga^+ FIB lithography, on the other hand, relies on the formation of a thin non-volatile mask on the silicon regions irradiated by the Ga^+ ions, when exposed to a fluorinated plasma such as SF_6 and Ar.[3]

The FinFETs were fabricated on SOI substrate, with a 120 nm thick silicon (Si) layer. The source and drain regions were covered with a 50 nm thick aluminum (Al), which was used as an etching hard mask. The multiple fins, with length of 7 μm, were defined in each devices using the Ga^+ FIB, with energy of 30 kV and current of 30 pA. In this step, the ion beam was used only for a shallow cut of the Si upper layer of the fin structure, as shown schematically in Figure 1. Figure 2a presents the device after fin definition. The Si etch was done using SF_6/Ar inductively coupled plasma (ICP) after the FIB step. The resulting fins are shown in Figure 2b and a cross section is in Figure 3. It is important to mention that the time required for the multiple fin definition by combining the Ga^+ FIB lithography and SF_6/Ar plasma etch techniques, is drastically reduced when compared to the traditional Ga^+ FIB milling. Thus, our fabrication method allows the definition of multiple fin structures within a short time.

Our method for multiple fin FinFET prototyping is fast and reproducible and enables advanced device fabrication and great flexibility regarding both the number of fins and fin width.

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[2] Santos, M. V. Puydinger Dos; Lima, L. P. B.; Diniz, J. A.; Filho, J. G. Journal of Vacuum Science & Technology B **31**, 06FA01 (2013)
[3] Henry, M. D.; Shearn, M. J.; Chhim, B.; Scherer, A. Nanotechnology **21**, 245303 (2010)

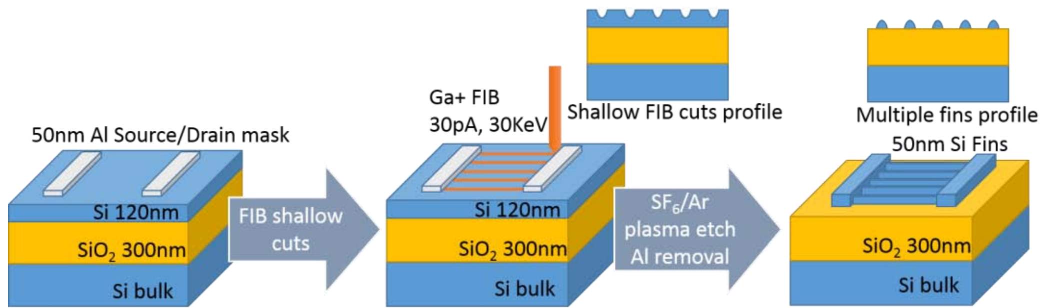

Figure 1: Schematic for the multiple fin definition using the Ga^+ focused ion beam lithography and plasma etch.

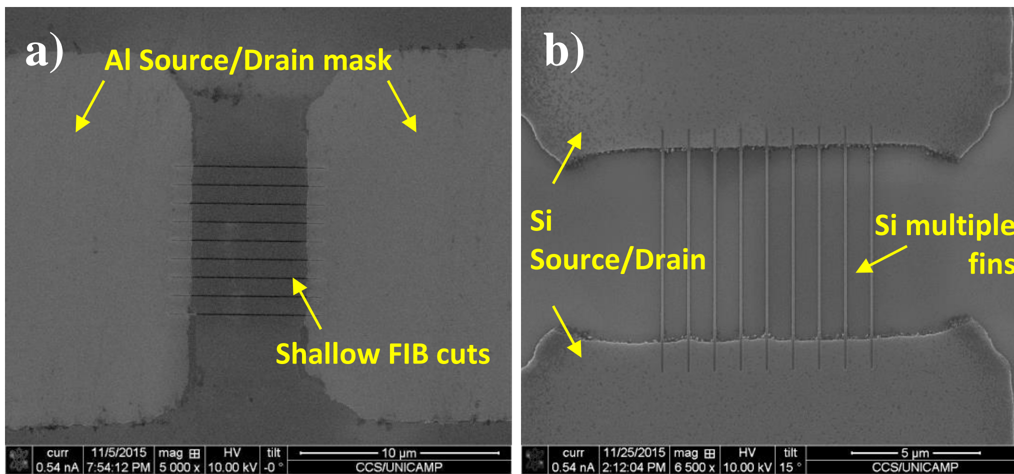

Figure 2: Multiple fin definition using the Ga^+ focused ion beam (a), and resulting fins after SF_6 and Ar plasma etch (b).

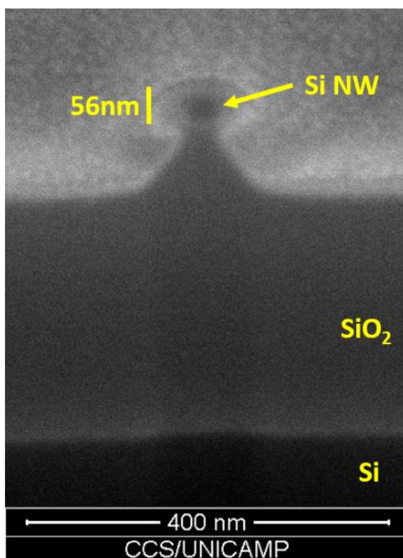

Figure 3: Cross section of a fin with sub-100nm dimensions.