

THREE-DIMENSIONAL NANOTECHNOLOGY BY FOCUSED-ION-BEAM CHEMICAL-VAPOR-DEPOSITION

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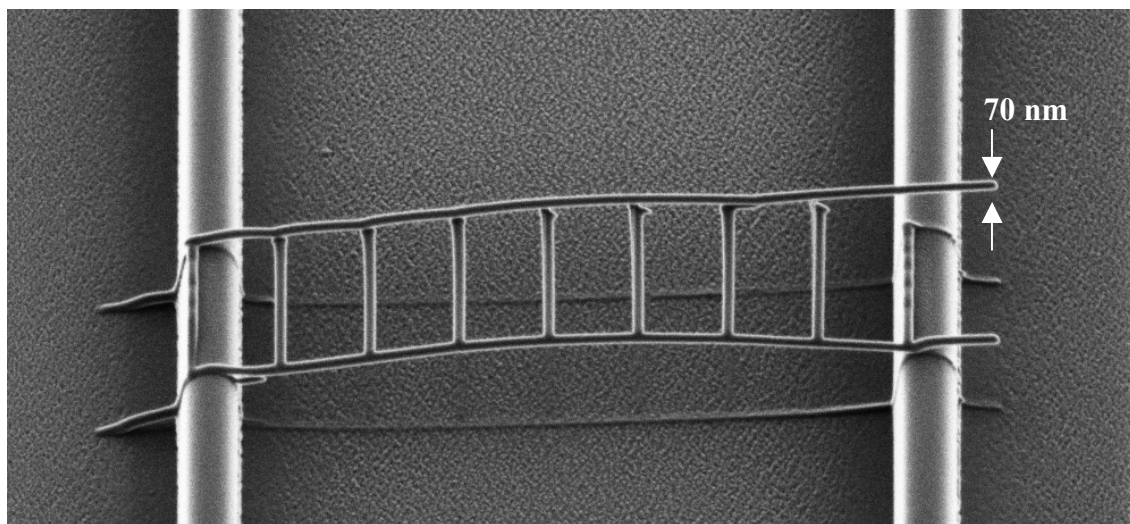
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The optical and electron-beam lithography are applied to make two-dimensional (2-D) wiring on a substrate in electronic or optical devices. On the other hand, focused-ion-beam chemical vapor deposition (FIB-CVD) seems to have big advantages and potential to make 3-D free-space-wiring. We previously reported on 3-D plastic art such as wine glasses, bellows, and coils fabricated using FIB-CVD.^[1] The key issue in making such three-dimensional work is the shallow penetration depth of the ions. This shallow penetration depth reduces the dispersion area of the secondary electrons, and thus the deposition area is tightly limited to within about several tens of nanometers. It is expected that novel device concepts such as a 3-D network are created by achieving 3-D free-space-wiring. This is the report on 3-D wiring fabrication by using FIB-CVD.^[2]

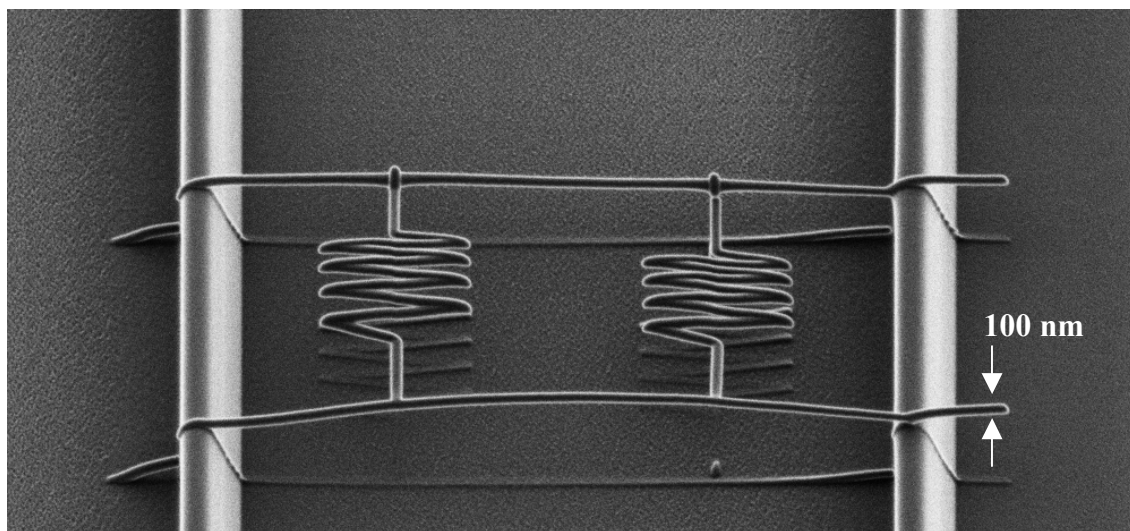
All experiments were carried out in a commercial available FIB system (SIM9200: SII Nanotechnology Inc.) with a Ga⁺ ion beam operating at 30 keV. The beam diameter was about 7 nm at 0.4 pA. FIB-CVD was done using a precursor of phenanthrene (C₁₄H₁₀) as a source material. The deposited material made of diamond-like carbon (DLC) with large Young's modulus. A computer controlled pattern generator (CPG1000: Crestec Co.) used in EB lithography was applied as a FIB scanning apparatus to fabricate 3-D free-space-wiring. Figures 1 (a) and 1 (b) show SIM images of DLC free-space-wirings fabricated by FIB-CVD. First, two parallel walls were made by FIB-CVD, and then free-space-wirings were formed between them by using a computer controlled pattern generator. Exposure times to make a ladder structure of Fig. 1 (a) and a parallel resistor structure of Fig. 1 (b) were 90 and 120 seconds. The free-space-wiring diameters of Figs. 1(a) and 1(b) were 70 and 100 nm. The results indicate that 3-D free-space-wiring can be achieved by using FIB-CVD. The resistivity measured by two terminal method was 100 Ω cm.

REFERENCES

- [1] S. Matsui, T. Kaito, J. Fujita, M. Komuro, K. Kanda, and Y. Haruyama: J. Vac. Sci. Technol., **B18** (2000) 3181.
- [2] T. Morita and S. Matsui et al.: J. Vac. Sci. Technol., **B21** (2003) 2737.



(a) Ladder structure



(b) Parallel resistor structure

Fig.1 Free-space-wiring fabricated by FIB-CVD