# Ultrananocrystalline diamond nanowires fabricated using electron-beam lithography and reactive ion etching

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## ABSTRACT

Diamond nanowires (NWs) and diamond nano-rods (NRs) are attracting much attention due to their extraordinary mechanical, electrical, and optical properties as predicated by theory for quasi 1-dimensional $sp^3$ nanostructures [1]. To date, only a few attempts have been reported, either by etching single crystal diamond lithographically to produce diamond NRs [2] or by coating Si NWs with nanocrystalline diamond to produce diamond NRs and NWs [3]. We report a method based on electron-beam lithography (EBL) and reactive ion etching (RIE) of ultrananocrystalline diamond (UNCD) films grown on Si substrates, to produce UNCD NWs with width in the range of 25-150 nm with well-defined spatial distribution and nanometer scale precision.

UNCD is grown by a microwave plasma chemical vapor deposition technique on an oxidized Si wafer, which has been coated with 10 nm of tungsten (W) [4]. The W thin film provides a surface that allows a high-density seeding to enhance nucleation for the growth of thin UNCD layers (70-100 nm). The UNCD films are synthesized by adding 20% of $N_2$ to the Ar-rich/$CH_4$ plasma to produce n-type UNCD films. The NW fabrication process flow is shown in Fig. 1, which reveals a cross-sectional view across the NW. The NWs with wider pads at both the ends for mechanical support and electrical contact are defined in HSQ through EBL (Fig. 1b). The pattern is transferred into the UNCD using an oxygen-based RIE etch that provides high anisotropy with good selectivity for UNCD over HSQ (Fig. 1c). Metal contacts and pads are made by optical lithography and Ti/Au lift-off (Fig. 1d). A 30 sec dip in HF prior to the metal deposition ensures the removal of HSQ from the UNCD-metal contact area. The W layer underneath the NW is removed with an isotropic flourine-based RIE etch that also removes the HSQ on the NWs and undercuts the oxide, hence releasing the NWs from the substrate (Fig. 1e). The undercut etch is timed such that the NWs are released but the wider contacts are still supported. An SEM image of the fabricated UNCD NW is shown in Fig. 2. The ability to fabricate UNCD NWs and UNCD NRs provides an opportunity to study the fundamental mechanism of transport processes in NWs, which will enable new ideas and possibilities for the fabrication of nanoelectronic devices and sensors with increased sensitivity and new functionalities.

### References

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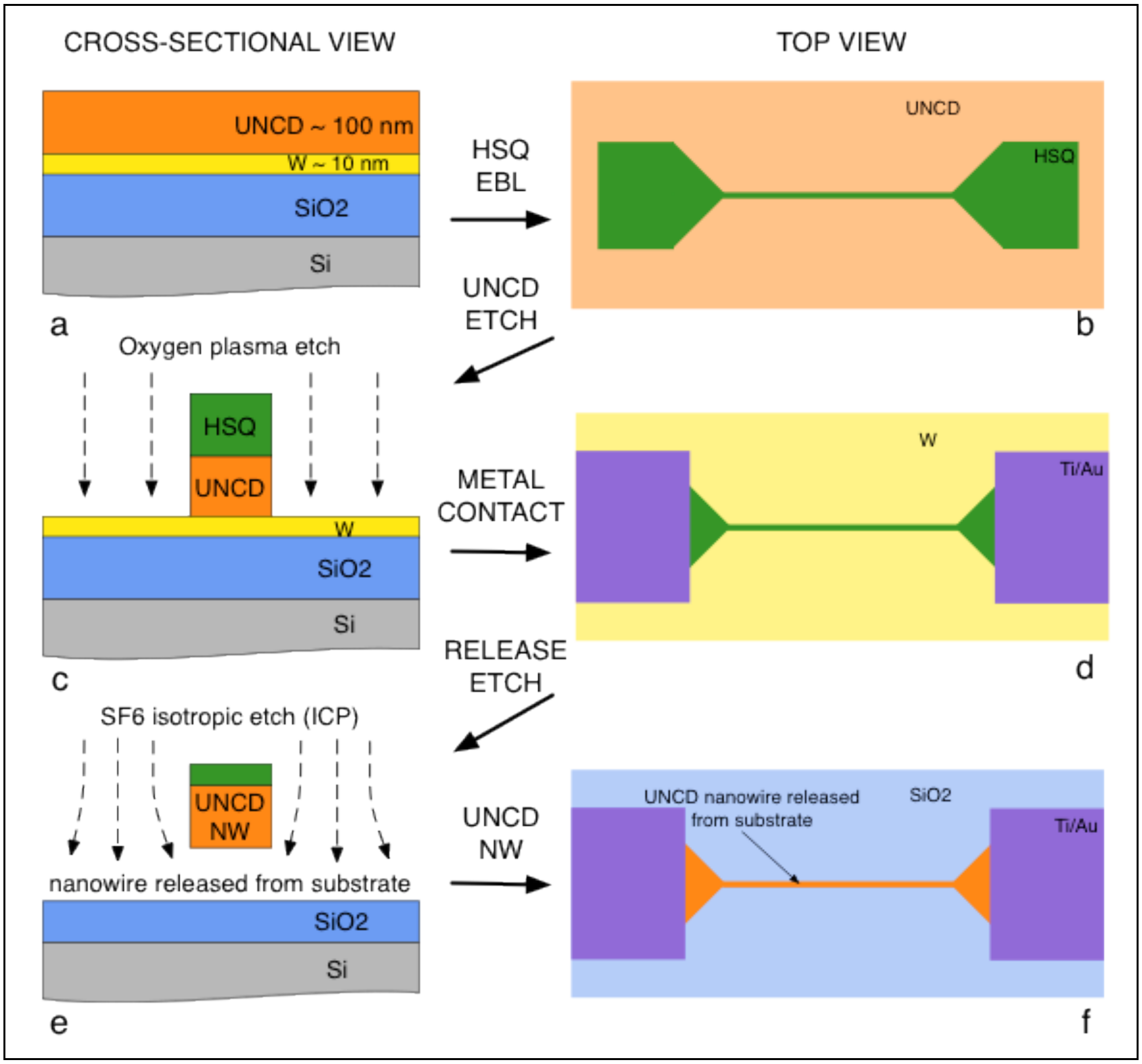


**Figure 1**. Process flow for UNCD NW fabrication.

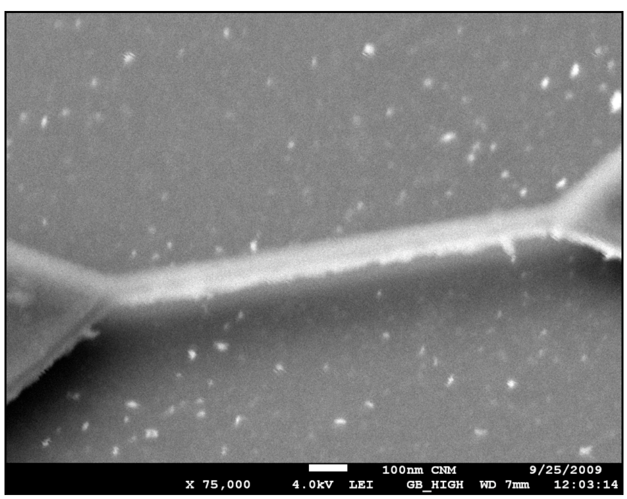


**Figure 2.** SEM image of a released NW supported on both sides by the wider pads.