Supplementary Information

Low-Temperature Plasma-Enhanced ALD of Highly Conductive Niobium Nitride Thin Films with RF Substrate Biasing

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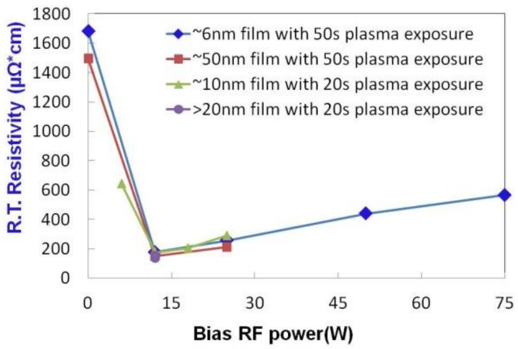

Fig.S1 Comparison of RT resistivity vs. RF bias power for NbN thin films grown at 250 °C with different plasma exposure time and ALD cycle numbers: effectively tuning of NbN thin films' conductivity is observed by control of the RF substrate biasing; the lowest RT resistivity of NbN films is achieved with the RF bias power at 12 W, which is independent of the plasma exposure time or film thickness.

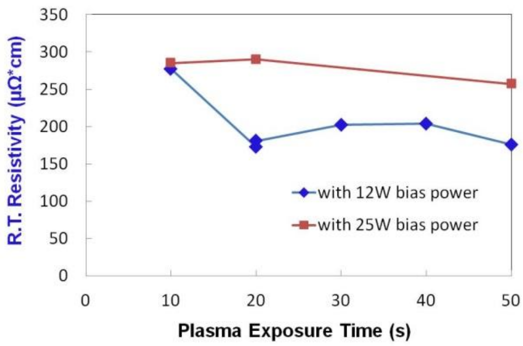

Fig.S2 RT resistivity as function of plasma exposure time for NbN thin films grown at 250 °C: with the RF bias power remained at 12 W, the plasma exposure time can be shortened to 20 s without obvious measurable change in film resistivity.

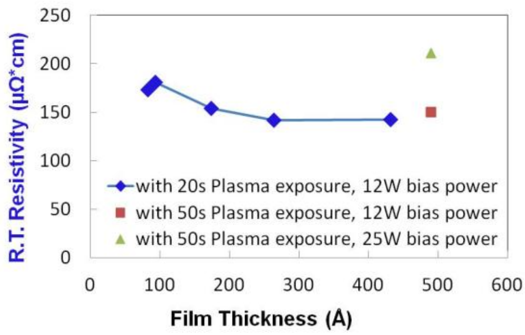

Fig.S3 RT resistivity as function of film thickness for NbN thin films grown at 250 °C: RT resistivity saturated above ~20 nm, for NbN films grown with 20 s plasma exposure and 12 W RF bias power. The resistivity of thick NbN films (>45 nm), grown with longer plasma time (50 s), is also shown.

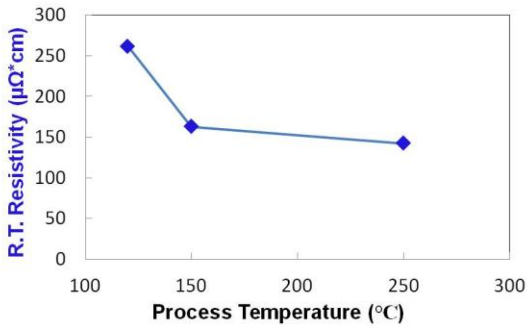

Fig.S4 RT resistivity stays low for NbN thin films (>20 nm) deposited at different process temperatures with the optimized process recipe (with a 20 s plasma exposure time, and 12 W RF bias power), which indicates a low temperature window (120 °C-250 °C) for highly conductive NbN PEALD process.