Growth and Nucleation of Low-Loss Titanium Nitride Superconductors on Silicon (111) using plasma assisted MBE

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Titanium nitride (TiN) is a known superconducting material that has demonstrated low-microwave-loss and used as passive components in superconducting quantum circuits for quantum information devices [1]. In contrast to conventional synthesis techniques, plasma assisted molecular beam epitaxy is used to produce low-loss TiN on bare silicon wafers. Using a rf-plasma source to crack the nitrogen molecules, and a conventional high temperature effusion cell for titanium, TiN growth is completed under nitrogen rich conditions to produce polycrystalline thin films that sit on an amorphous nitride layer. The motivation and activities pursued to synthesize epitaxial TiN on silicon that is compatible with the requirements of superconducting quantum circuits will be discussed.

A number of techniques are used to characterize the structure of the material, while cryogenic tests down to 80 mK characterize the superconducting properties. Coplanar waveguide resonators operating at 5 GHz demonstrate single photon quality factors above 1M, and high-power quality factors that approach 7M without observing saturation.

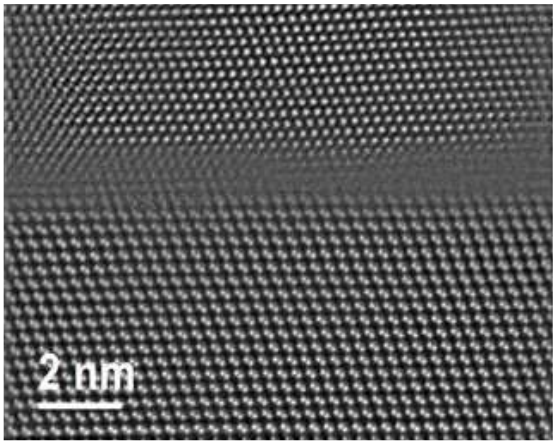

Figure 1 STEM image of the Si (111) substrate, TiN (111) film, and amorphous interface

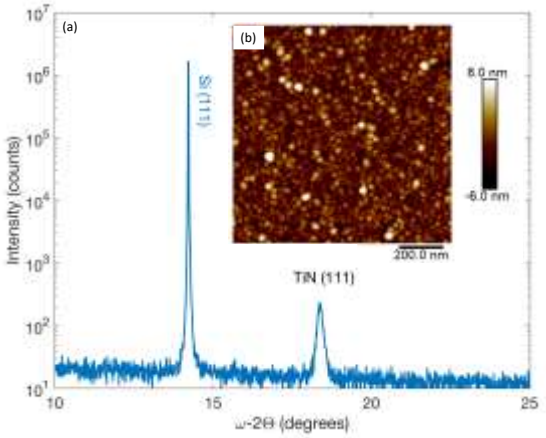

Figure 2 (a) XRD showing TiN on Si (111) texture and (b) AFM topology of the film surface.

[1] J. B. Chang, M. R. Vissers, A. D. Córcoles, M. Sandberg, J. Gao, D. W. Abraham, J. M. Chow, J. M. Gambetta, M. B. Rothwell, G. A. Keefe, M. Steffen, and D. P. Pappas, *Appl. Phys. Lett.* **103**, 012602 (2013).

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Supplementary information:

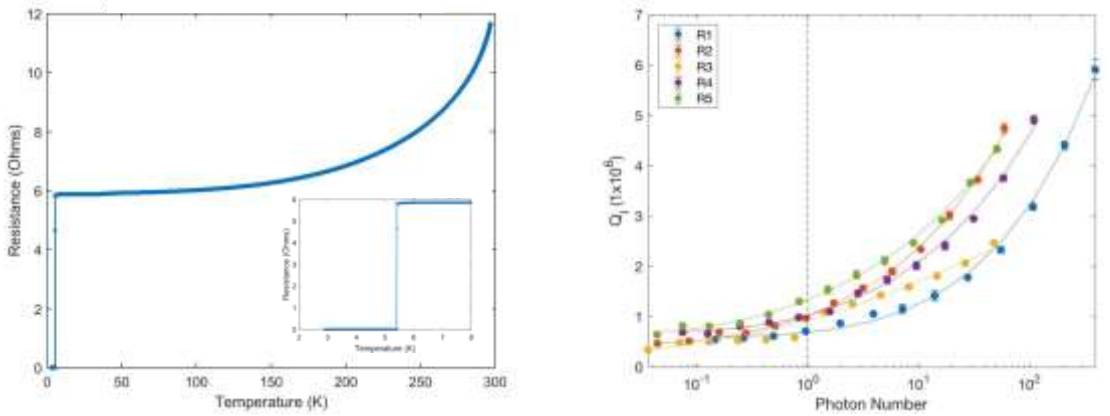

Figure (3) (left) DC resistance measurement with inset zoomed in around Tc, (right) power dependent internal quality factor of 5 GHz superconducting ¼-wave coplanar waveguides.