Residual Stress in Tungsten Thin Films for Photon Counting Applications

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We report on tungsten thin films used for superconducting transition-edge-sensors (TES) that are capable of accurately counting the number of photons, which can be exploited in astronomical and quantum-information applications.

The superconducting transition temperature (*Tc*) of tungsten films was found to strongly depend on the deposition conditions and the existence of an underlayer or coating. For instance, a film with *Tc* of about 100 mK is under tensile stress when grown on bare Si wafers, whereas another film with *Tc* of 200 mK is under compressive stress when grown on in-situ sputtered amorphous Si. Furthermore, coating tungsten films with SiO_2 suppressed *Tc* below 60 mK. Sputtered tungsten thin films usually contain two crystallographic phases: α-W (bcc) with *Tc* of 15 mK, and β-W (A15) with *Tc* between 1 to 4 K. Thus, *Tc* might be influenced by both phase composition and stress associated with the deposition and neighboring layers.

We used laboratory and synchrotron (APS high-energy 6-ID-MU beamline) X-ray diffraction to assess both the phase composition and residual stress state in tungsten films at room and low (8 K) temperatures. Results indicate no significant changes in phase composition in this temperature range. Residual stress at room temperature did not strongly vary among the films, indicating that the changes in *Tc* are likely due to additional thermal stress induced by cooling to cryogenic temperatures.

Keywords: residual stress, thin films, tungsten