Investigation of superconductivity in ultrathin PtSi films formed by employing a novel self-alignment process

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Schottky barrier (SB) transistor is used in a variety of applications. Recently, Platinum silicide (PtSi) has been investigated as the metallic source and drain terminals of SB metal-oxide-semiconductor field-effect transistors in cryogenic CMOS as well as in quantum bits (qubits) based on nanoscale Josephson field-effect transistors (JoFETs) [1]. The formation of superconducting PtSi film usually starts from physical vapor deposition (PVD) on a precleaned silicon substrate of a platinum layer, followed by rapid thermal processing (RTP). The superconductivity in ultrathin PtSi films formed by employing a novel self-aligned process, i.e., thermal oxidation and selective removal of unreacted Pt in aqua regia after silicide formation [2], is characterized in the present work. Although severe agglomeration of the 3.1 nm thick PtSi film after the thermal oxidation at 600 ^{o}C is observed (Fig. 1), the superconductivity prevails with a higher critical temperature (T_C) than that of its precursor as-formed film at 500 ^{o}C (Fig. 2). Rutherford backscattering spectrometry (RBS) was employed for Pt thickness calibration while grazing incidence X-ray diffraction (GIXRD) for both confirmation of the PtSi formation and estimation of the PtSi grain size according to the Scherrer equation (Fig. 2). The continuous increase in T_C could be correlated to the monotonous increase in average grain size when the PtSi film thickness increases for both as-formed and oxidized films. Of special interest is the doubling of the estimated average grain size (thickness) in the oxidized sample with 3.1 nm PtSi, which fits well with the estimated severe reduction of surface coverage by 50% (Fig. 1) of the agglomerated PtSi film. The results clearly indicate that T_C is governed by the property of the best percolating path in a superconducting film. Furthermore, new process solutions to mitigating the agglomeration of sub-5 nm thick PtSi films have been developed.

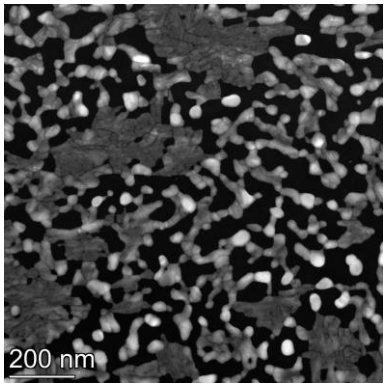

Fig. 1 Plan-view, high-angle annular dark field (HAADF) TEM image for a 3.1-nm PtSi sample after sequential RTP in N_2 at 500 °C for 30 s and in O_2 at 600 °C for 60 s [2]. Bright parts are PtSi while dark parts are exposed Si.

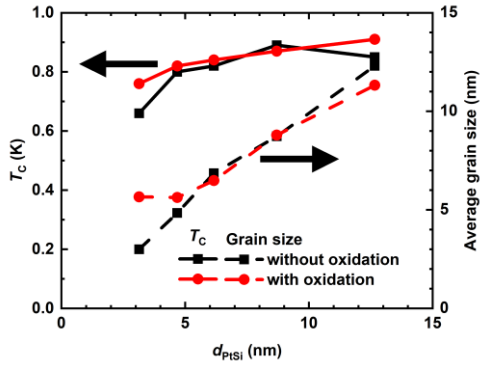

Fig. 2 Critical temperature, T_C, and average grain size as a function of PtSi thickness, d_{PtSi}, for PtSi films formed at 500 °C with or without subsequent thermal oxidation.

References

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