^{3}He Effect on 2D Superfluidity in ^{3}He-^{4}He Mixture Films on Planar Gold

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There have been a number of studies exploring the nature of 2D superfluidity and configuration of ^{3}He-^{4}He mixture films on various substrates. At T = 0, ^{3}He tends to float on top of underlying ^{4}He due to the different zero point energies, and the overlayer ^{3}He strongly affects the 2D superfluidity. A previous torsional oscillator study[1], in a thick ^{3}He overlayer ($n_3 \sim 136$ μmol/m^2), reports an extra depletion of the superfluid density at low temperatures and a suppression of the superfluid transition temperature, yet mechanism of ^{3}He effect on the 2D superfluidity has not been settled. We present here a result of QCM (quartz crystal microbalance) measurements on planar gold substrate. Our measurements are done by keeping a constant ^{3}He coverage (0, 1.7, or 19.0 μmol/m^2) and then adding ^{4}He. For the mixture films with $n_3 \sim 1.7$ μmol/m^2, no effect of ^{3}He on the superfluidity is observed. However, for $n_3 \sim 19.0$ μmol/m^2, we observe a strong effect of ^{3}He on the superfluidity as well as the previous study[1]. It is suggested, as one of possible scenarios, that ^{3}He in the mixture films reduces the vortex core energy above a critical value of ^{3}He between 1.7 and 19.0 μmol/m^2.

[1]D. McQueeney, G. Agnolet and J. D. Reppy, Phys. Rev. Lett. **52**, 1325 (1984).