Search for Magnetism in HfO_2 Thin Films

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A recent intriguing report of the observation of unexpected and highly anisotropic ferromagnetism in the high-κ dielectric oxide HfO_2 thin films [1] has stirred the scientific community. If validated, this discovery of d^0 ferromagnetism in a transparent oxide undoubtedly represents a major advance for the field of spintronics [2]. Interestingly, the high-κ dielectric oxides such as HfO_2 are already under active consideration as gate dielectrics for next generation devices in semiconductor technology in view of the material compatibility with silicon [3]. Introducing a magnetic response in such dielectrics should enable an integration of complementary metal-oxide semiconductor (CMOS) with spintronic technology. The magnetic moment, derived from magnetization measurements, found by various groups in HfO_2 thin films is about 0.1 μ_B per formula unit.

From preliminary bulk studies [4] it was deduced that different muon states are present in HfO_2: μ^+, Mu^0_{atomic}, and, for $T < 50$K, $Mu^0_{shallow}$. Differently to these findings, our preliminary low energy μSR (LE-μSR) study on HfO_2 thin films grown c-cut sapphire reveals a dominant μ^+ signal (derived from ZF/TF measurements). A pronounced two component depolarization in the whole measured temperature range ($T = 4 \ldots 200$K) is observed. We attribute the fast depolarization as due to magnetism consistent with the macroscopic measurements (and not due to muonium depolarization/diffusion processes). We will discuss possible mechanisms which could lead to d^0 ferromagnetism.

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