Ultra-Low-Damping Epitaxial YIG Films Grown by LPE with a Buffer Layer for Quantum Applications

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The pursuit of quantum-coherent magnonic systems demands ultra-low-damping materials operable at mK temperatures—a domain where conventional YIG films fail due to interfacial paramagnetic relaxation. Overcoming the "GGG bottleneck" (Gd^{3+} diffusion below 100 K) remains critical for scaling quantum-hybrid architectures. While bulk YIG crystals achieve near-theoretical damping limits, thin-film counterparts suffer from inhomogeneous broadening that masks intrinsic properties [1]. Our approach targets this fundamental disparity by decoupling crystal perfection from substrate-induced spin decoherence.

In this work we continue to study cryogenic properties of LPE grown YIG [2,3]. We demonstrate record-low ferromagnetic resonance (FMR) linewidths in epitaxial yttrium iron garnet (YIG) films at cryogenic temperatures, achieved via a novel $Y_3(GaScIn)_5O_{12}$ buffer layer grown by liquid phase epitaxy (LPE). The buffer eliminates gadolinium diffusion from the GGG substrate, suppressing paramagnetic damping below 100 K. Low intrinsic damping do not provide narrow FMR linewidth [4], but alongside with structural perfection of single crystal inhomogeneous broadening can be significantly lowered. FMR measurements reveal linewidths of 1.82 Oe at 4 K and 1.83 Oe at 14 mK—the lowest values reported for thin-film YIG. Lattice mismatch is minimized to 0.0025 Å through tailoring In^{3+} substitution, ensuring homogeneity. Optimized LPE synthesis with PbO-B_2O_3 solution-melts enables scalable production. The films show quantum-ready performance in dilution-refrigerator environments (14 mK), critical for hybrid quantum systems. This interfacial engineering approach overcomes intrinsic limitations of GGG substrates, reducing paramagnetic influence on intrinsic magnetic damping and provide low inhomogeneous broadening of FMR. Cross-sectional SEM and XRD confirm structural integrity and strain mitigation. The results establish YIG films as viable components for cryogenic spintronics and quantum magnonics.

Bibliography

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