Analysis of nanometer-thin yttrium iron garnet (YIG) films on a 3-inch wafer scale

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Poster presentation

Nanometer-thin yttrium iron garnet (YIG) films are a potential base material for future nanoscale magnonic circuits that could be used as building blocks for magnonic networks for spin-wave-based data processing due to their unique magnetic and microwave properties. The fact that it is already possible to increase the usable film surface of this material to a diameter of up to three inches makes it interesting for the production of a variety of nanoscale spin-wave circuits on the same wafer. However, this requires a high degree of perfection and homogeneity of the films over the entire sample diameter as well as appropriate methods for the quality inspection of nanometer-thin yttrium iron garnet films on a 3-inch wafer-scale. The aim of this study was therefore to determine the perfection, homogeneity and reproducibility of important film properties over 3-inch wafer surfaces and volumes. This was carried out for different wafers prepared in the same run and for wafers prepared in different runs to determine the specification range that can be reproduced by the applied liquid phase epitaxy (LPE) deposition technique.

The characterization of the 3-inch YIG films was carried out by optical and X-ray methods, atomic force microscopy and microwave techniques using ferromagnetic resonance analysis. Brewster angle reflectometry, spectral reflectance and X-ray fluorescence methods were applied to analyze the film thickness in order to determine its quantitative values and homogeneity over the entire sample diameter. To analyze the surface roughness, atomic force microscopy scans were performed over 20 µm × 20 µm areas to ensure that they are ready for the microfabrication of nanoscale microwave structures. To determine the characteristic FMR properties such as the inhomogeneous line broadening ΔH_0 and the intrinsic Gilbert damping coefficient α, frequency-dependent measurements of the resonant RF-power absorption bands were carried out to determine the absolute magnetic losses at the required frequencies over the entire sample. In order to determine the homogeneity of the efficiency of the generated spin currents across the Pt/YIG interfaces, spin mixing conductivity measurements were performed at different locations on 3-inch wafers. The results presented show the typical, reproducible specification range that can be achieved using liquid phase epitaxy technology and that the film quality on a 3-inch wafer scale meets the requirements for future magnonic circuits.

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