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Magnetic fluid based on YIG and Ce:YIG: glycothermal synthesis and magneto-optical properties

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Yttrium iron garnet ($Y_3Fe_5O_{12}$, YIG) is a reference material in modern photonics [1]. Due to its wide band gap (2.5–2.9 eV), forbidden d–d transitions, high transparency in the near-infrared region, large Faraday rotation, and excellent chemical stability, YIG is a prime candidate for integrated optical isolators. Moreover, partial substitution of Y^{3+} by Ce^{3+} enhances its magneto-optical response [2]. In the context of ferrofluids, Ce incorporation can enhance the specific Faraday rotation while maintaining good optical transparency in the near-infrared region. As a result, Ce:YIG ferrofluids represent highly promising candidates.

However, producing YIG and Ce:YIG at the nanoscale remains challenging. Common chemical synthesis routes, such as co-precipitation and sol–gel methods, require high-temperature post-treatments (800–1400 ℃) to form the garnet phase [3]. These temperatures are needed to overcome the high crystallization energy of YIG, but they also promote particle growth and coalescence, typically resulting in particle sizes from about 80 nm to the micrometer range.

In this work, we explore a different strategy to overcome these limitations. Rather than relying on high temperatures, we use a seed-mediated solvothermal synthesis to guide garnet crystallization [4]. By introducing isostructural seed nanoparticles, we aim to bypass the nucleation barrier that normally requires extreme thermal activation. This approach enables the production of magnetic fluids containing particles with sizes around 20 nm.

The YIG and Ce:YIG magnetic fluids were characterized using several complementary techniques to evaluate both their optical quality and magneto-optical (MO) properties. The measured Faraday rotation and ellipticity spectra, obtained by magneto-optic polarimetry, closely match those of YIG single-crystal films. This approach opens new pathways towards size-controlled, phase-pure YIG nanostructures suitable for MO nanocomposites and magneto-optical materials compatible with integrated photonic platforms.

References

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Type:
Poster