The growth and optical properties of high concentration of ErAs embedded within GaAs

Y. Wang[1], D. Wei[1], C. Ni[1], S. Law[1], J. Zide[1]

[1] *University of Delaware, Newark, Delaware 19716, United State*

We report the MBE growth and the optical properties of ErAs:GaAs nanocomposites with high ErAs concentration. The study is motivated by looking for a novel composite III-V material as alternative plasmonic material in the short-wave to mid infrared range. ErAs, which is the most studied material in Lanthanide Arsenides (also referred as rare-earth arsenides), is interesting for a wide range of applications. The rock-salt crystal of ErAs shares common arsenic sublattices with many technologically important zincblende III-V semiconductors such as GaAs. High quality ErAs:III-V films can therefore be grown epitaxially on III-Vs with tunable properties by adjusting the ErAs concentration and growth conditions. In this work, we investigated the MBE growth of ErAs:GaAs nanocomposites with ErAs% up to ~52% using a co-deposition method. ErAs:GaAs films were grown at substrate temperatures ranging from 450°C to 600°C under As2 overpressure with various Er effusion cell temperatures in order to study the effects of both ErAs concentration and growth temperature on material properties. The high ErAs% is confirmed by Rutherford backscattering spectrometry. Fourier transform infrared spectroscopy was used to study the optical properties of the materials. Reflection data show that the as-grown ErAs:GaAs films have tunable plasma wavelength across the 2.68~6 μm window as higher ErAs% leads to shorter plasma wavelength. Higher growth temperature also tends to result in slight blueshift of the plasma wavelength. The shifts of plasma wavelength of these ErAs:GaAs films grown with different parameters are consistent with the changes in carrier concentrations studied from Hall Effect measurements, as higher ErAs% or higher growth temperature leads to larger electron concentration. Besides the influence on plasma wavelength, the scattering rate also decreases as the growth temperature increases either due to better crystallinity or change in morphology of ErAs nanoinclusions. A detailed TEM study is underway to understand the morphology and crystallinity of ErAs embedded in GaAs grown with various parameters, which potentially lead to tunable properties of the films. Furthermore, Drude formalism is applied to get preliminary modelling and understanding of the optical properties of these ErAs:GaAs films, and it agrees well with the experimental reflection data. The wide growth temperature range, plasmon response tunabililty and the ease of epitaxial combination of the ErAs:GaAs films with other conventional III−V semiconductors show a great potential for many novel optoelectronic and nanophotonic applications in the 2-5 μm range where there are very few plasmonic materials.