Proceedings of the 10th World Congress on New Technologies (NewTech'24)
Barcelona, Spain - August 25-27, 2024
Paper No. ICNFA 137
DOI: 10.11159/icnfa25.137

Electrochemical Formation and Optical Characterization of Indium Phosphide Nanoparticles

Hasan Yüngeviş[1], Sabriye Açıkgöz[1]
[1]Karamanoğlu Mehmetbey University
Karaman, Turkey
hyungevis@kmu.edu.tr; sabriyeacikgoz@kmu.edu.tr

Extended Abstract

Indium phosphide (InP) is a III–V semiconductor with a direct bandgap and high electron mobility, perfect for optoelectronic and photonic devices. The nano structuring of indium phosphide (InP) surfaces has been extensively researched to improve light–matter interactions, surface reactivity, and device performance [1] [2].

This research offers a simple and versatile method for creating nano-scale particles on indium phosphide (InP) semiconductor surfaces through a double-cell electrochemical etching process in a hydrochloric acid (HCl)–ethanol (C_2H_5OH) solution. The formation mechanism of the InP particles was investigated by varying current density and etching time. A home-made electrochemical etching tool was used for the experiments. Morphological and chemical analyses were carried out using a scanning electron microscope (Hitachi SU 5000) equipped with energy-dispersive X-ray spectroscopy (EDX).

Nano-scale particles with diverse sizes and densities were formed on indium phosphide semiconductor wafers as a function of the applied etching parameters. After two minutes of etching at a current density of 30 mA/cm² in a 1:1 HCl–ethanol solution, InP particles with an average size of approximately 54 nm were produced. When the current density was increased to 40 mA/cm² under the same conditions, smaller particles formed, averaging around 33 nm. Extending the etching duration to 6 minutes under the same conditions, was resulted in the formation of larger InP particles, along with an increased particle density on the surface.

The optical properties and carrier recombination behaviour of the synthesized nanoparticles were analysed using steady-state photoluminescence (PL) spectroscopy (Thorlabs CCS175-M) and a custom-built time-resolved fluorescence lifetime imaging microscope (FLIM). The FLIM technique was used to generate two-dimensional maps of emission intensity and carrier recombination lifetime for InP surfaces of varied sizes. These maps were used to examine the relationship between surface morphology, fluorescence emission intensity, and carrier recombination lifetime.

Thus, we have developed a method for the formation of nanoparticles on the InP wafer surface via an electrochemical etching process in an HCl solution and conducted a broad analysis of the optical properties of these InP surfaces.

References

[1] Niu Yanping, Ma Shufang, Dong Haoyan, Yang Zhi, Hao Xiaodong, Han Bin, Wu Shengli, Dong Hailiang, Xu Bingshe Characterization and Growth Mechanisms of Low Dimensional InP Materials[J]. Chinese Journal of Luminescence,2024,45(05):779-793.

[2] Hagar Marouf, Nariman Abdel-Salam, El-Sayed M. El-Rabaie, Ahmed Nabih Zaki Rashed, Khalil M. ElKhamisy "The Effect of Different Nanoparticles Surface Plasmon Polariton (SPP) Grating on Ge, Si, InP, and GaAs Photodetectors Performance," Plasmonics (2025).