**Abstratct**

In this study, gallium nitride (GaN) thin films were deposited on porous silicon (PSi) substrates via pulsed laser deposition method (PLD) under different growth conditions of laser wavelengts (355, 532, and 1064 nm), laser energies (600 – 1000 mJ), and substrate temperatures (200- 400℃). Photoelectrochemical etching method (PECE) assisted by a diode laser was used to synthesize PSi substrates under different etching parameters of currrent density (10 – 60 mA/cm$^2$), and etching time (2.5, 5, 7.5,10, 12.5, 15 Minute). The effect of different laser wavelengths, laser energies, and substrate temperatures on the the structural, topographical, morphological, spectroscopic, optical, and electrical properties of GaN thin films were studied. As well as, the performance characteristic of fabricated GaN/ PSi heterojunction photodiode were tested. XRD results showed the fabricated GaN/ PSi heterojunction photodiodes were wuritzite hexagonal with a high hexagonal crystallographic structure at (002) plane at 355 nm and 900 mJ, and at (100) plane at 300 ºC.

The photoluminescence (PL) measurements showed two emission peaks attributable to GaN films in the utraviolet band (UV) and to synthesized Psi substrate in the infrared band (IR). The topographical results confirmed the AFM image demonstrates uniform deposition of samples with largest average particle diameter and average surface roughness fabricated using laser wavelength of 355 nm, laser energy of 900 mJ, and 300 ºC.substrate temperatures. The morphological results confirmed the FE-SEM images showed a cauliflower-like morphology. GaN/PSi heterojunction photodetectors had rectification in their dark I-V characteristics, and the heterojunction made at 355 nm, 900 mJ, and 300 ℃ had the best junction characteristics.

The best performance characteristics of GaN/PSi heterojunction photodiode shows spectral responsivity of 29.011 A/W, detectivity of $8.02\times 10^{12}$ Jones, and external quantum efficiency of 97.2 % at 370 nm, respectively at growth conditions of 355 nm, 900 mJ, and 300 ºC. As well as showed a fast rise time of 328 µsec and a fall time of 617 µsec to use it in the UV detection applications with high performance.

Organic- inorganic ITO:PEDOT:PSS:PMMA:GaN hybrid junction and of ITO:PMMA:GaN hybrid junction were fabricated using PLD method under different laser pulses of 200, 250, and 300. Optical investigation showed the fabricated ITO:PMMA:GaN hybrid junction at 300 laser pulse has PL emission in the UV-Visible and red bands. As well as the electroluminescence (EL) measurements showed all the EL emission at 300 laser pulse.