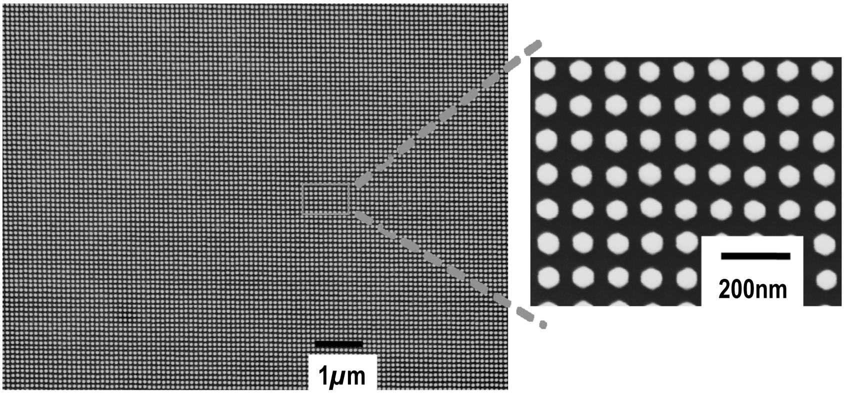
Site-Controlled Group-III Nitride Quantum Dot Nanostructures

Luke Lee and P. C. Ku



The scanning electron micrograph of the two-stack InGaN quantum dots structures embedded in GaN barriers after the removal of the dielectric nanoscale selective area epitaxy mask.

Semiconductor quantum dots (QDs) play a crucial role in many optoelectronic and electronic applications. In III-nitride material systems, QDs not only can improve light emitting efficiency but possess unique properties such as permanent dipole moment due to strong polarization, long spin coherence time, large phonon energy, and possible room-temperature ferromagnetism with magnetic dopants. These properties make III-nitride QDs particularly interesting for nanophotonics, quantum information, and spintronics applications. In many applications, it is often desirable to have site-controlled, highly uniform and dense QDs. III-nitride QDs are typically fabricated by the Stranski-Krastanow growth but they exhibit large nonuniformity and random locations. This project explores methods of fabricating III-nitride QDs that are site controlled, uniform, and exhibit a high density. We use nanoscale selective area epitaxy (NSAE). NSAE has been demonstrated to be viable in forming semiconductor nanostructures. The main challenge of this project is to further push the NSAE technique in forming III-nitride heterostructures that exhibit three-dimensional quantum confinement: each dimension must be only a few Bohr radii (~3nm in III-nitride.) Currently, we have achieved a two-stack InGaN QD array with a density $>1e10/cm^2$. The dot height and lateral dimension are 3nm and 30nm, respectively. This project is supported by the University of Michigan, College of Engineering Start-Up Funds.