Surface modification of GaN/GaAs/Si by Ar plasma irradiation with radio frequency biasing for optical applications

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In the past decades, surface-modified semiconductors have been attractive for various optical applications due to the strong interaction between light and micro/nanostructures on the semiconductors. “Random lasers”, based on coherent optical feedback in nanostructures with sizes on the order of wavelengths are one of the promising candidate applications of surface-modified semiconductors. Random lasing using semiconductor gain media have recently been studied as speckle-free light sources that are particularly well-suited for use in sensors and full-field imaging. However, the conventional nano-lithography processes for semiconductors, such as reactive ion etching, are complex and high-cost and probably cause surface damage resulting from the hundreds of electron voltages of ions bombardment, which degrades the photoluminescence performance. In addition, laser nanofabrication also concerns a small processing area and low throughput.

In this study, a simple, low-cost, and large-area processing method to fabricate nanostructure on semiconductors is presented. Optically-active semiconductors such as gallium nitride (GaN), gallium arsenide (GaAs), and silicon (Si) are surface-modified by argon (Ar) plasma irradiation with radio frequency (RF) substrate biasing. Unique nanostructures with sizes on the order of visible wavelength have successfully been obtained as shown in Fig. 1. The detailed plasma processing properties and photoluminescence characteristics were evaluated. At the conference, we will also report on our concept of optical device applications represented by random lasers.

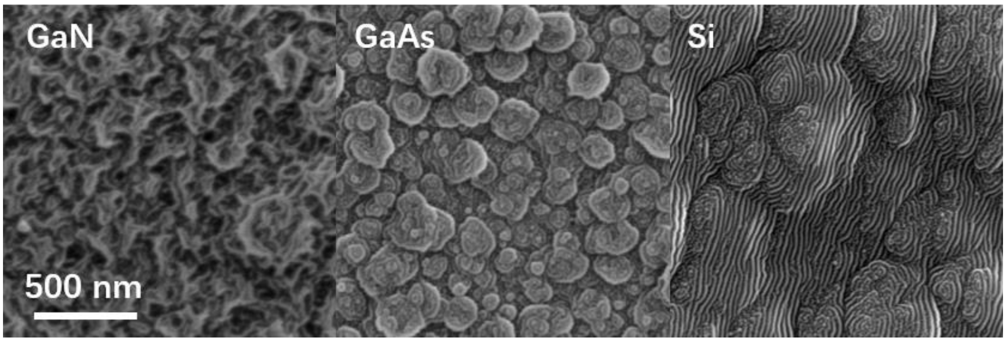

Fig. 1. Scanning electron microscopic images of nanostructure on (from left to right) GaN, GaAs, and Si irradiated by Ar plasma at fluence of 2.4×10^{-25} m^{-3}. The power of RF biasing is 15 W.