Nano/micro-structures formation on various semiconductors by argon plasma irradiation assisted with molybdenum impurity

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Nanostructure formation on semiconductors can be well controlled by plasma etching with lithography. However, these methods usually contain multiple steps that are complex and time-consuming. Recently, with the assistance of a small amount of impurities deposition, nano/micro-structures can be easily formed on Si and GaN by noble gas plasma irradiation [1,2]. The morphology of the plasma treated surface can be partially controlled by the amount of impurity and ion energy. Therefore, it is interesting to extend this technique to other semiconductors for a better understanding of the influences of properties of semiconductors on the formation of nano/micro-structures and to find a promising simple method to fabricate semiconductor nano/micro-structure.

In this study, a series of semiconductors with different sputtering yields and band gaps, such as Ge, Si, GaAs, ZnSe, GaN, and SiC have been irradiated by Ar plasma with Mo impurities co-deposition. Volcano-like structures with different features were formed on the surface of different semiconductors, as shown in figure 1. The size and density of the structure can be changed by changing the deposition rate of Mo impurities. The formation process of these structures was discussed by checking the structures at different irradiation time. However, it is difficult to form any structure on both Si and SiC, due to the low etching selectivity to Mo for Ar plasma. Features of different semiconductors have been discussed in accordance with the characteristics of morphologies after plasma irradiation. Moreover, the absorbance of surface modified semiconductors has been measured to examine the band structure.

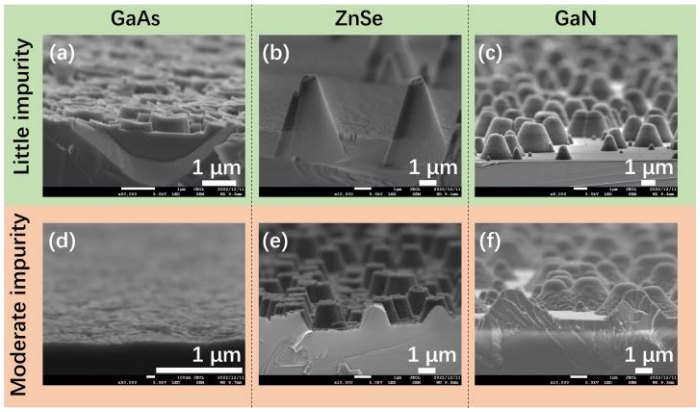

Fig. 1. SEM image of nano/micro-structures from the side view of (a) GaAs, (b) ZnSe, and (c) GaN with little impurities deposition. SEM image of nano/micro-structure from the side view of (d) GaAs, (e) ZnSe, and (f) GaN with moderate impurities deposition.

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[2] Q. Shi, H. Fujiwara, S. Kajita, R. Yasuhara, H. Tanaka, N. Ohno, H. Uehara, Structural Correlation of Random Lasing Performance in Plasma-Induced Surface-Modified Gallium Nitride, ACS Applied Optical Materials. https://doi.org/10.1021/acsaom.2c00085.