PLATHINIUM
PLASMA THIN FILM INTERNATIONAL UNION MEETING
13-17 September 2021
Antibes, French Riviera
WWW.PLATHINIUM.COM
100% VIRTUAL

Novel methods for tuning film properties using nanostructures

Masaharu SHIRATANI

Kyushu University, Fukuoka (JP)

We have developed three novel methods for tuning film properties using nanostructures: controlling nucleation in gas phase, nucleation on substrates, and nucleation under catalysts. They correspond to nanoparticle composite film deposition, inverse SK mode deposition and sputtering-assisted metal-induced layer exchange. The nanoparticle composite films are deposited using nanoparticles and radicals formed in reactive plasmas [1]. Chemical reactions on nanoparticles take place much faster than those on substrate surface, especially at low substrate temperatures, because nanoparticles of a low heat capacity become high temperature due to heating from plasma and they have a large surface to volume ratio. Utilizing this feature, we have succeeded high quality SiNx films at a low substrate temperature of 100 ^{o}C. The inverse SK mode is a new mode of hetero-epitaxial film growth, in which stress is relaxed in an atomically flat buffer layer consisted of nanocrystals aligned in-plane and out-of-plane and single crystal with a low defect density grows on the buffer layer [2]. To realize the buffer layer of this mode, we applied impurity-mediated sputtering. Nitrogen was employed as an impurity for ZnO film fabrication. We obtained single crystal ZnO on sapphire with a large lattice mismatch of 18%. The inverse SK mode opens great possibilities of single crystal hetero-epitaxy of multicomponent systems with a wide mixture range. The impurity-mediated sputtering provides an alternative method for amorphous film formation at high substrate temperatures. We applied this method to obtain amorphous ITO films with a high mobility. The metal-induced layer exchange is a well-known method of crystal film formation on glass and polymer. We reduced the processing time by 2-3 orders of magnitude and the processing temperature using a sputtering-assisted metal-induced layer exchange method [3]. By applying the method, we succeeded in crystalline Ge formation on polyamide films at 150 ^{o}C in a short processing time of 10 min. In addition to these film fabrication methods, we will show film properties and some device applications. In particular, by combining a novel inverse SK mode with a novel material of ZnInON, we demonstrated room temperature operation of an excitonic transistor, a novel ultra-low energy consumption and ultra-fast switching device with an optical input and output.

References

[1] S. H. Hwang, et al., Jpn. J. Appl. Phys. 59 (2020) 100906. [2] N. Itagaki, et al.,Sci. Rep. 10 (2020) 1. [3] S. Tanami, et al., Thin Solid Films 641 (2017) 59.