The Development of Non-polar Wurtzite AlN Microcrystal Films on SiO_2 Glass Substrates

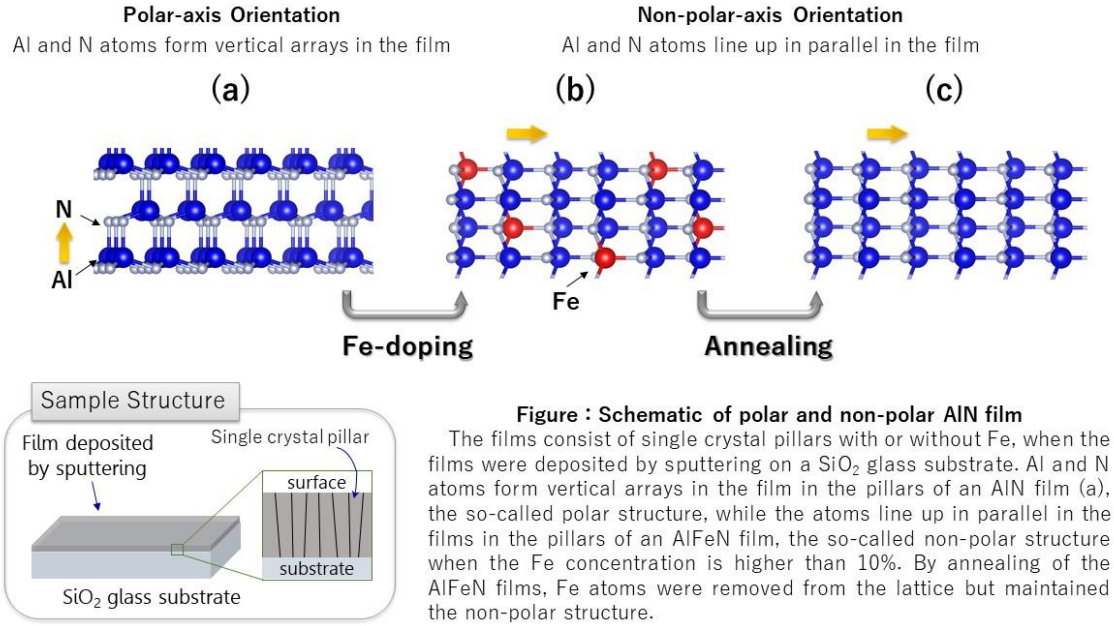
A research team led by the Kyoto Institute of Technology has developed a new technique to synthesize non-polar wurtzite aluminium nitride (AlN)-based polycrystal-like films on glass substrates. This research was published online in *Scientific Reports* (Springer Nature) at 10:00 on the 4th of February 2020, London local time (19:00 on February 4th, 2020 in Japan).

Wurtzite aluminium nitride (AlN) is a wide- and direct-band-gap semiconductor that is a promising material for deep-ultraviolet (DUV) optoelectronic devices, such as light-emitting diodes (LEDs) or laser diodes (LDs). As the energy of deep ultraviolet light is high enough to sterilize and decompose toxic molecules, it is useful in the fields of medicine and healthcare. At present, DUV light sources are mercury lamps and metal halide lamps, which require a measurable amount of power, have a short life-span, and are large in size. To replace the lamps with LED systems that will be energy-saving, long-lasting, and small, the design and development of DUV-LEDs have been sped up around the world.

In the course of the studies, however, it became evident that AlN and related materials have difficult issues in realizing high efficiency devices owing to some electronic properties in the form of thin films, which are traced back to the crystal axis orientation of AlN, *i.e.* the polar-axis orientation. Therefore, non-polar-axis oriented AlN films have generated a lot of interest, because they can avoid these problems.

In 2018, the research team had succeeded in growing non-polar-axis-oriented wurtzite films by heavy-doping of Fe in AlN films [1]. The Fe-doped AlN (AlFeN) films were grown reproducibly on various substrates include SiO_2 glass substrates by sputtering, which is a conventional industrial technique for liquid crystal panels, solar cells and so on. The reseach group, however, found that the Fe-doping raised large gap states in the gap of AlFeN. Such gap states cause low efficiency of light emission via traps of carries and reabsorption of emitted light. To remove the gap states, the research group conducted annealing of the films and succeeded in desorption of Fe atoms from the AlFeN lattice, resulting in a drastic decrease of the gap states while maintain the non-polar axis orientation.

The new technique developed by the research team will be able to supply seed layers to construct non-polar AlN-based DUV-LEDs without expensive substrates or machines. Currently, it is only a very small seed. However, the research team plans to complete a higher quality seed layer to realize high-efficiency DUV-LEDs at low cost in the future.



Figure：Schematic of polar and non-polar AlN film

The films consist of single crystal pillars with or without Fe, when the films were deposited by sputtering on a SiO_2 glass substrate. Al and N atoms form vertical arrays in the film in the pillars of an AlN film (a), the so-called polar structure, while the atoms line up in parallel in the films in the pillars of an AlFeN film, the so-called non-polar structure when the Fe concentration is higher than 10%. By annealing of the AlFeN films, Fe atoms were removed from the lattice but maintained the non-polar structure.

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Reference

[1] N. Tatemizo, *et al*., "Wurtzite [11-20]-oriented AlFeN films prepared by RF sputtering", AIP advances, **8**, 115117 (2018).

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