Method of Increasing III-Nitride Semiconductor Growth Rate

A method for extremely high growth rates in PAMBE growth of GaN while maintaining a smooth surface microstructure

Georgia Tech inventors have achieved extremely high growth rates in PAMBE growth of GaN while maintaining a smooth surface microstructure. The higher rates were reached with added pumping capacity and a minor modification to the plasma source, while a mixed chemistry plasma showed a further enhancement of the growth rate. Suppression of ion content is achieved by higher plasma pressure and through argon dilution. The maximum achieved growth rate of 9.8 µm/hour represents more than an order of magnitude increase compared to traditional growth rates in MBE, and even exceeds those commonly used in MOCVD. To overcome a challenge introduced by the higher growth rates, the inventors explored the use of alternative n-type doping methods. The high growth rates, resulting low unintentional doping levels, and excellent uniformity over large areas opens the door for the use of MBE for novel devices utilizing thick indium-bearing layers, as well as existing devices where the traditional slow growth in MBE was previously not viable.

Summary Bullets

- Faster growth rates result in reduced epitaxy cost
- Ability to grow at lower temperatures reduces thermal budget, stress and wafer bowing
- Ability to grow pseudo-substrates of any III-nitride alloy composition

Solution Advantages

- Faster growth rates result in reduced epitaxy cost
- Ability to grow at lower temperatures reduces thermal budget, stress and wafer bowing
- Ability to grow pseudo-substrates of any III-nitride alloy composition
- Substantially lower operational costs due to use of pure elemental sources
- Lack of necessity for thermal cracking

Potential Commercial Applications

- LEDs and lasers, particularly for green emitters
- Power electronics and RF applications where thick buffers are used
- Photovoltaic cells (solar cells)

- Bulk III-nitride growth

Background and More Information

Group III-nitride semiconductors have seen enormous commercial growth in recent years for solid-state lighting and power electronics. Light emitting diodes (LEDs) can be grown by plasma-assisted molecular beam epitaxy (PAMBE), in which typically a radio frequency (RF) plasma generates reactive nitrogen species from inert nitrogen gas. PAMBE’s been shown to result in higher growth rates and improved surface morphology compared to other plasma techniques. Also, the relatively low growth rates limit the applicability of PAMBE for many devices which require thick buffer layers. Although the ultra-clean environment of MBE can beneficial, the slow growth rates still preclude the use of MBE for such devices. If rapid growth of indium-bearing layers can be achieved, then the potential of III-nitrides for photovoltaics improves dramatically.

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Publications

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Images

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