HP1.30

Efficiency Enhancement in AlGaN Deep-UV LEDs Using High-Reflectivity Al-based p-type Electrode

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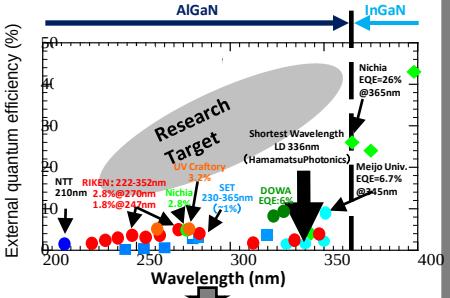
Background

External Quantum Efficiency of AlGaN DUV LED



EQE of AlGaN DUV LED is still low .

● External Quantum Efficiency (EQE)

$$\eta_{ext} = \eta_{int} \times \eta_{ext} \times \eta_{inj}$$

η_{ext}	η_{int}	η_{ext}	η_{inj}
External Quantum Efficiency (EQE)	Internal Quantum Efficiency (IQE)	Light Extrction Efficiency (LEE)	Light Extrction Efficiency (LEE)

λ	η_{ext}		η_{int}		η_{inj}		η_{ext}
250nm	0.43	=	25%	×	22%	×	8%
247nm	1.8%	=	〃	×	>80%	×	8%

50~80% is achieved by low TDD AlN

Improved by introducing MQB

Further Improvement is necessary.

Approach

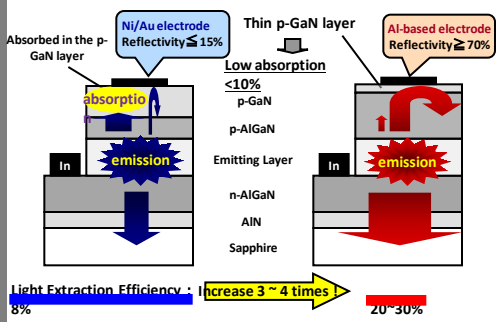
Improvement of Light Extraction Efficiency in DUV LED

Introducing the

● **High-reflectivity Al p-type electrode**

&

● **Thin p-GaN contact layer**



This work

● Investigation of
- p-GaN Transmittance
- Reflectivity of Al-electrode

● Realization of High-EQE DUV-LED using Al electrode and thin p-GaN layer.

Fabrication process

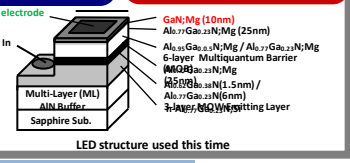
● The sample were grown on sapphire (0001) substrates LP-MOCVD

Using thin p-GaN layer;10nm

● p type activation anneal for 50 minutes at 830℃ under the nitrogen atmosphere.

< Ni/Au Electrode >
- Ni:25
- anneal for 10 minutes at 500℃ under the nitrogen atmosphere

< Al-based Electrode >
- Ni:
- Using the thin Ni to suppress the photoabsorption
- non-anneal processing

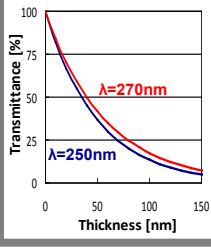


LED structure used this time

Transmittance of p-GaN

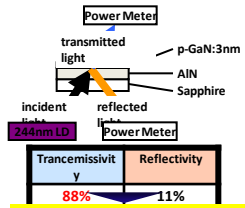
Theoretical value

● Transmittance of this GaN



Measurement

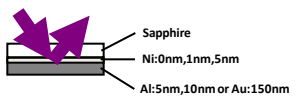
● Transmittance of p-GaN (3nm)



The transmittance of p-GaN (10nm) is estimated to be about 60%

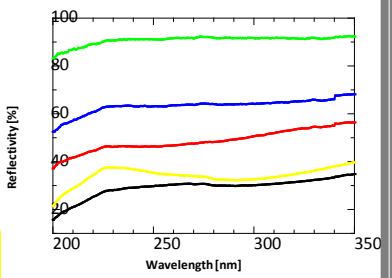
Reflectivity of Al-electrode

● Reflectivity of variety of Ni/Al thickness
(Ni/Al was deposited on transparent sapphire substrate.)

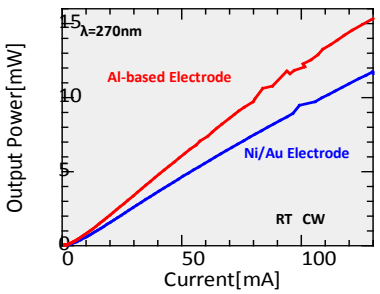


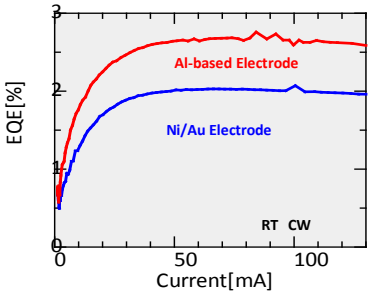
Ni/Al [nm]		0/100	1/50	1/100	5/100	Ni:25/Au:150
Reflectivity [%]	250nm	91.1	46.3	63.1	35.3	29.7
	270nm	91.5	47.5	63.7	33.9	30.5

Al electrode shows high-reflectivity compared with conventional Ni/Au electrode.



270nm DUV LED with Al-based electrode

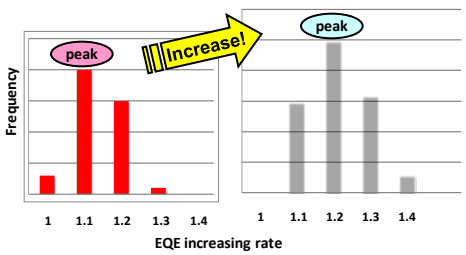




Max output power: 15.6mW, highest EQE: 2.75%

LEE increase by use of thick Al-electrode

(i) Ni: 1nm / Al: 50nm (ii) Ni: 1nm / Al: 100nm



● Structure:

AlGaN-QW DUV-LED with MQB-EBL
- p-GaN: 10nm
- p-electrode:

Ni(1nm)/Al(100nm)

● High-reflectivity can be obtained for Thick Al-electrode

● LEE increases by 1.3 times by using Al-electrode

Summary

● High LEE was obtained by using high-reflectivity Al p-electrode and thin p-GaN contact layer.

● High EQE 270nm DUV LED was achieved.
highest EQE: 2.75% , Max CW power: 15.6mW, Output power: 2.2mW @ 20mA