# Improvement in the Description of the First DBR-LED and a Proposal of Solution Growth for an Ideal LED

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## 1. Introduction

Light-emitting diodes with distributed Bragg reflector (DBR-LEDs) were invented in 1989 as an application of Metalorganic Vapor Phase Epitaxy (MOVPE). At the time, DBR was called BR. This invention was granted patents [1]. Ref .2 is the first English paper on this invention. An important mission of the present paper is that the originator improves the description of that English paper for the reference in developing LEDs. The light output of the DBR-LEDs was 1.6 times of that of the LEDs without the DBRs in the origination of DBR-LEDs, as first publicly reported in the world [3]. The MOVPE has intrinsic problems. The gases are dangerous and wasted.

In this origination, the author observed that the efficiency of LEDs fabricated with solution growth was higher than the DBR-LEDs. Then, the author proposes solution growth for the fabrication of LEDs.

## 2. DBR-LED in the Origination

*Structure (Fig. 1) and Fabrication*

The DBR-LEDs adopted AlGaAs system. The material of substrate and active layer was GaAs. The substrate absorbs the emitting light. The cladding layers were transparent. The electrodes were metals and not transparent.

The semiconductor layers were grown by MOVPE.

*Emitted Light -Improved Description-*

The DBRs reflected the emitted light and increased the light output. The light wavelength spectra oscillated due to the interference between the light extraction surface and DBR. By roughing the light extraction surface, this oscillation was disappeared. The output more increased and became 1.6 times of that of the LEDs without DBRs.

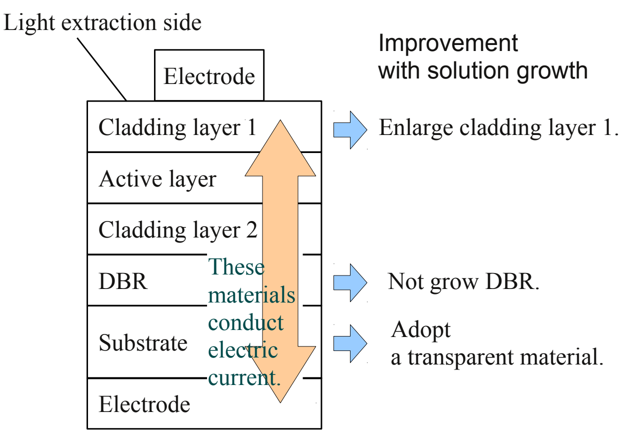


Fig. 1. Schematic illustration of DBR-LED and an improvement with solution growth. Main parts are shown. The other parts such as contacting layer, buffer layer and so on are omitted.

*Discussion on the Above Improvement*

Ref. 2 showed that the output of DBR-LEDs exceeded twice of that of the LED without DBR. However, the author's experiment showed that the output of DBR-LEDs was less than twice of that of the LED without DBR. It was thought that the thickness of cladding layer 1 (Fig. 1) in the LED without DBR in Ref. 2 was smaller than that of DBR-LEDs. MOVPE is not suitable for growing large thickness layers. In the normal operation, the large thickness layers were not grown.

## 3. Solution Growth

Solution growth proceeds almost in equilibrium between the solid and liquid phases and has complementary characteristics to MOVPE. Solution growth techniques grow high quality crystals, can grow large thickness layers, save resources and is safer.

Transparent large thickness layers (Fig.1) increase the efficiency of LEDs more than DBRs. It was observed in the origination of DBR-LEDs.

Therefore, the present paper proposes solution growth in fabricating LEDs.

However, when poorly soluble solutes are included, the growth is impossible (e.g., red LEDs). New techniques beyond current applied physics must be invented. Therefore, the author begins from establishing mathematical basis [4] for the systematic approaches, exceeding one discipline.

## 4. Conclusions

The previous English description on the efficiency of DBR-LEDs was improved as first publicly reported in the world (in 1989). Solution growth was proposed for fabricating LEDs because it makes the efficiency of LEDs higher than DBR-LEDs, saves resources and is safer than MOVPE.

## References

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