Efficiency enhancement in GaN-based blue to blue-violet LDs by engineered nitride-oxide ohmic contacts

Y3 Newsletter—2022/2023

Project at a glance

OBJECTIVE

To overcome the difficulties in ohmic contact fabrication to GaN LDs by introducing a novel contact scheme utilizing a bandgap engineered transparent conducting oxide (TCO) and interface engineering by appropriate GaN surface pre-treatment or ultrathin film deposition.

WHY AZO?

A sustainable material, ZnO:Al (AZO) is a promising indium-free TCO for transparent contact applications. Through alloying with Mg, band gap engineering and refractive index tuning is possible to address desirable optical properties while maintaining low resistivity.

TECHNICAL OUTCOME

The technical goal of the proposal is to present a packaged LD demonstrator with improved efficiency using the new contacts.

GET IN TOUCH

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Comments, business inquiries, future collaborators? We'd like to hear from you:
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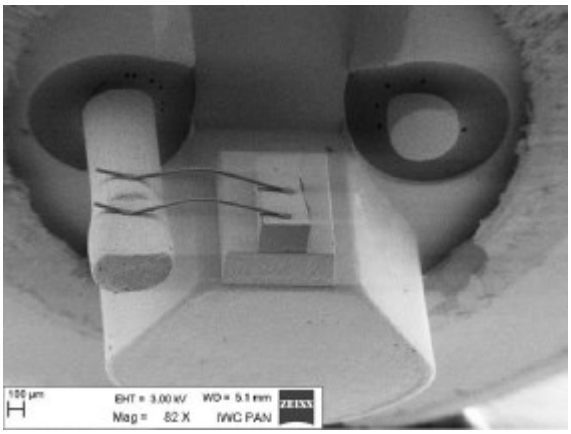
Project news

Final year of realization of the project

The project started on September 1, 2020. After focusing on optimizing the AZO and Mg-alloyed AZO transparent conducting films in the first year, the development of reliable ohmic contacts to N-face n-GaN and Ga –face p-GaN in the second year, the third year of the project saw work on laser device structures ending with a full packaged demonstrator, as planned.

Both top and bottom contacts were prepared using oxide-based electrodes based on AZO, fully encompasing the Oxy-GaN name of the project. The lasing emission linewidths were narrow, the contacts lent themselves to conventional photolithography patterning and were readily bonded to the TO56 packaging and hermetically sealed. The parameters of the final diode were better than of a reference one with conventional metallic contacts. Additional details can be found on the following page.

Individual LD **Mounted LD** **Packaged LD**



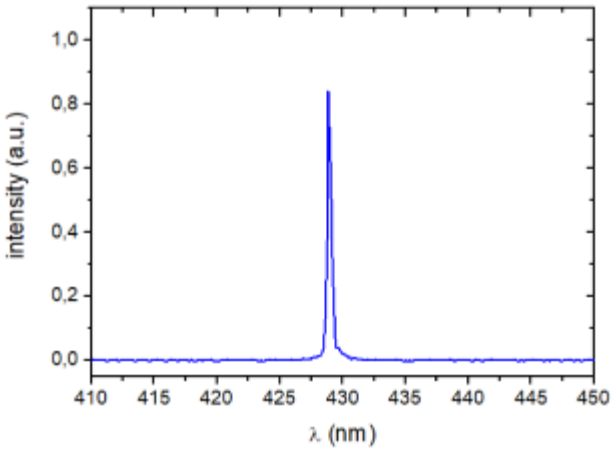
The 5 partners involved in the consortium are leaders in their respective fields and encompass a full value chain for material and LD research, development and manufacture as well as advanced characterization:

- Institute of Microelectronics and Photonics, Łukasiewicz Research Network (Łukasiewicz-IMiF, co-ordinator)
- Institute of High Pressure Physics, Polish Academy of Sciences (Unipress)
- Institute for Technical Physics and Materials Science, Centre for Energy Research (EK)
- Technion – Israel Institute of Technology (Technion)
- TopGaN Lasers inc. (TOP-GAN)

OxyGaN is a project realized within the m-era.net 2019 multilateral call and financed by the National Centre of Research and Development, Poland grant no. M-ERA.NET2/2019/6/2020, by the Hungarian NRDI Fund, grant number 2019 2.1.7 ERA NET 2020 00002 and by the Israel Ministry of Science, Technology and Space

Main achievements of the project

Example of emission from LD with oxide contacts



The project OXYGaN set out to realize a new approach to the technology of ohmic contacts enabling easier deposition—using the same material for both p-type Ga-face GaN and n-type N-face GaN at the same time improving the contact performance. To do that, AZO was chosen as the transparent conducting electrode and interface engineering was planned to achieve good contacts to both n and p-type. At the end of the project, the following have been achieved:

- developing better than state-of-the-art AZO films deposited at room temperature with record low resistivities. Room temperature deposition enables lift-off patterning;
- understanding the process of AZO band gap engineering by adding Mg using different sources: Mg and AZO targets as well as a single compound target;
- developing efficient p-type ohmic contact through ultrathin interlayer insertion at the interface. The exact mechanism of contact formation is still puzzling;
- developing good ohmic contacts to n-type N-face GaN by interface processing and interlayer insertion;
- fabricating a fully packaged demonstrator diode at TRL 6 with all oxide contacts, the performance of which is better than reference diodes with classical metallic contacts, in terms of contact resistivity, threshold voltage, current stability after lifetime testing as well as lower degradation after 100 hours at constant optical power.

These results enable to say that project goals were reached.

Dissemination of project results

The final year saw six conference presentations, at both national and international conferences. One of the most important is the one accepted for an oral presentation at the 14th International Conference on Nitride Semiconductors in Fukuoka with dr Szymon Grzanka presenting. This presentation concerned the main results of the project and its title was: Performance of oxide-based versus to metal-based contacts for InGaN laser diodes. What is especially important is that this conference is the biggest forum of specialists in GaN-based technology, and having this presentation accepted underlines its value for the community.

Worth mentioning is also the invited talk on the alloying of AZO with Mg to achieve ZnMgO:Al which was presented in may 2023 in Croatia, at the 1st Croatian Ceramic Society International Conference

A summary of the project for the Polish audience planned in 2024 by invitation on the Solid State Physics Seminar at the Physics Department of Warsaw University.

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