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

Y2 Newsletter—2021/2022

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

WWW: oxygan.ite.waw.pl

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

2nd 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 second year of realization saw a focus shift to the development of reliable ohmic contacts to N-face n-GaN and Ga –face p-GaN.

The first publication of the project was published in the Vacuum (Q1) journal and the OxyGaN workshop was held in Budapest to disseminate knowledge on technology of wide band gap materials.

In the final year of this three-year project, we will want to demonstrate a packaged operational 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:

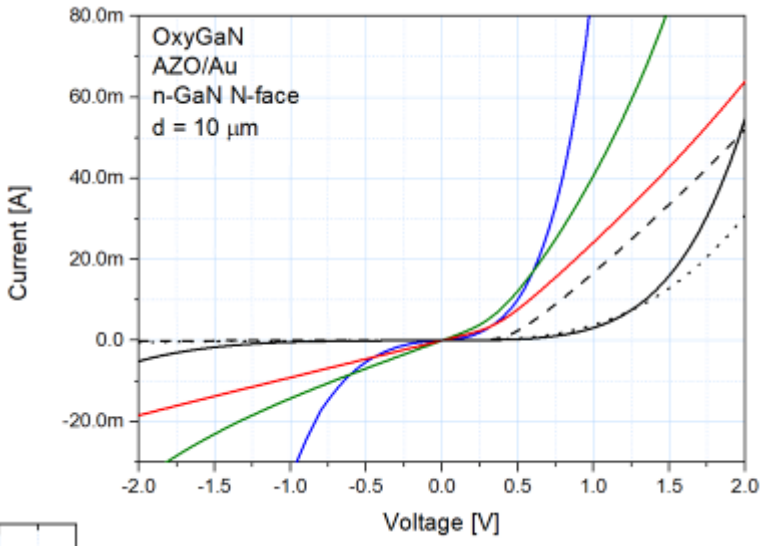
- Institute of Microelectronics and Photonics, Łukasiewicz Research Network (Łukasiewicz-IMiF, co-ordinator)
- Institute of High Pressure Physics, Polish Academy of Sciences (Unipress)
- Institute for Technical Physics and Materials Science, Centre for Energy Research (EK)
- Technion – Israel Institute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

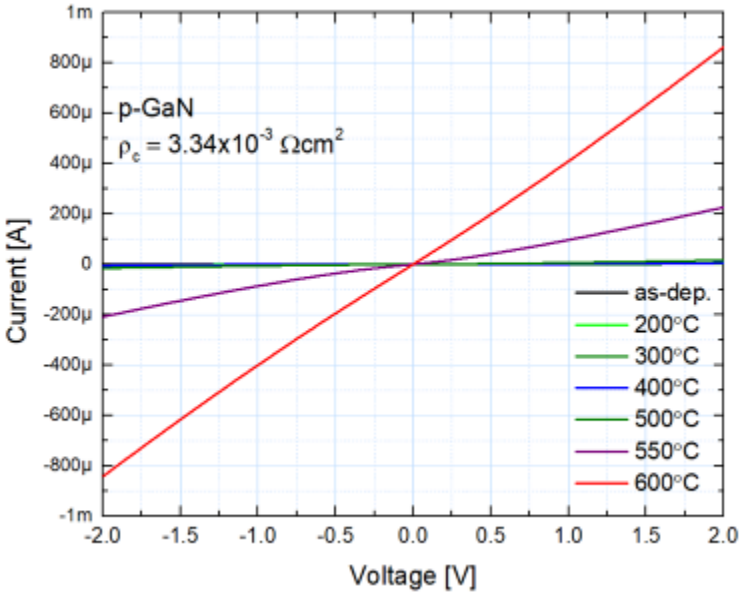
OxyGaN is a project realized within the m-era.net 2019 multilateral call and financed by the National Centre of Research and Development, Poland grant no. M-ERA.NET2/2019/6/2020, by the Hungarian NRDI Fund, grant number 2019 2.1.7 ERA NET 2020 00002 and by the Israel Ministry of Science, Technology and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

Interface engineering of AZO-based contacts to n-GaN and p-GaN

In forming ohmic contacts to wide bandgap semiconductors, gallium nitride in particular, the role of the interface states is crucial. This is why the team of OxyGaN has been investigating how to modify the interfacial properties of the GaN surface both in the case of N-face n-GaN and Ga-face p-GaN.

We have applied modifications based on: wet chemical treatment, dry plasma treatment and ultrathin metallic interlayer deposition. We show that the junction properties of GaN/AZO were influenced significantly by the chosen protocol.



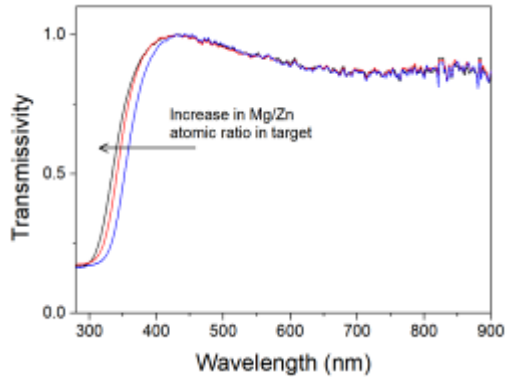


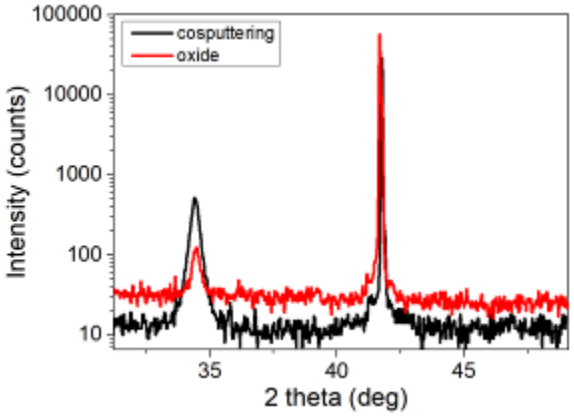
Above, N-face n-GaN surface was treated with different wet and treatments as well as plasma etching. While in the newsletter we cannot uncover the plot identification, the significant difference in the trends shows the importance of proper substrate treatment.

A similar approach for contact modification with ultrathin interfacial metallic films showed that it was possible to achieve very low contact resistivities by introducing a specially prepared metallic interlayer—this enabled an ohmic contact profile, which was further included in tests on full device structures.

AZMO targets for transparent electrodes

After last year's approaches with determining the optimal composition of ZnMgO:Al (AZMO) films, bespoke targets were ordered with different Mg content to see if they would allow to recreate the results from multi-target sputtering. We got similar crystalline structure, good conductivity and transparency of the films, which we could change, depending on the Mg content. All in all—a success.





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Dissemination of project results

2022 saw much more mobility and conference participation than 2021!
The participants in project gave 13 presentations on the results of OxyGaN at international conferences and workshops. Particularly worth mentioning are Szymon Grzanka's oral presentations at the International Workshop on Nitride Semiconductors in Berlin and Aleksandra Wójcicka's oral presentations at the Materials Research Society's Fall Meeting in Boston (right) and at the European MRS Fall Meeting in Warsaw. The acceptance of the abstracts for oral presentations at these conferences underlines the high quality of the obtained results.

A. Wójcicka at the MRS conference in Boston

The full list can be viewed on the project website at: http://oxygan.ite.waw.pl/2023/03/20/2022-dissemination-of-results/

Additionally, after a lengthy review process, the following publication has been published in Vacuum (Q1):

- Aleksandra Wójcicka, Zsolt Fogarassy, Adél Rácz, Tatyana Kravchuk, Grzegorz Sobczak and Michał A. Borysiewicz, "Multifactorial investigations of the deposition process – material property relationships of ZnO:Al thin films deposited by magnetron sputtering in pulsed DC, DC and RF modes using different targets for low resistance highly transparent films on unheated substrates" https://doi.org/10.1016/j.vacuum.2022.111299

OxyGaN workshop was organized in Budapest

Networking leads to new ideas and growth, therefore the OxyGaN team planned to use part of the granted funding to reach outside of the project consortium to share the competences and results with international colleagues working on the technologies of wide band gap materials and devices. Within the workdhop format, each speaker had a much longer time for their presentation, enabling more in-depth coverage and engaging discussions. The workshop was organized by the Centre for Energy Research, Institute of Technical Physics and Materials Science in Budapest Hungary on the 27th may 2022.

There were over 15 participants in person and a similar number online. A very packed full day of presentations gave the participants overview of some of the most exciting developments in gallium nitride and gallium oxide technologies. Intensive discussions took place after every presentation and ideas for new research activities also emerged.

The detailed program can be found online at http://oxygan.ite.waw.pl/2022/05/23/oxygan-workshop-2022%ef%bb%bf-programme/.

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