NEWSLETTER

OPTICA

Advancing Optics and Photonics Worldwide

Optics for Energy

CONTENT

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FOREWORD

Mission and Goals

The group aims to connect professionals and students in optics and energy through: Technical events ,Educational webinars, Networking activities, Social media engagement.
MUCH MORE would be possible with your contributions!

Meet the team

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OPENING MESSAGE

By Banafshe Zakeri

“**Always start with why”;** That’s a famous quote from *Simon Sinek,* the author of the book “Start with why”, and I think it’s a great idea to help us make sense of the things we do before even getting into the details. When you want to start a project, ask yourself why I want to do that! When you are selling a product, tell to your customers first why they should buy it! When you start writing a book, write in the very first pages, why your readers should spend time and read it to the end! For me, since I started this approach, the outcome was very helpful, especially for decision making. But if you are honest with yourself when answering this question of “why”, you see that sometimes it might not be an interesting answer at the first shot. However, if you believe in what you do, the answer will ultimately turn to a fascinating story.

Now, may I ask you “why are you a member of OPTICA Optics for Energy technical group?” Let me guess! You are here probably because you are doing or willing to do something related to energy and you’ve been hopeful that the content of some webinars might be somehow helpful for your study, research, job, ... Academia has always trained us to search for new information, which is great by the way. However, chasing after new information sometimes makes us to underestimate the knowledge and experiences that we have acquired along the way. Let’s finally make use of them. What you know might be something that someone else desperately needs. Share what you have and let’s serve this community together. We will get to a fascinating story of **“why we are here”**!

CALL FOR COMMITTEE MEMBERS

For executing our plans and having new exciting events for the group, we aim to add two new positions in the committee team:

Industry officer:

Goal: Planing regular events for bridging academia and industry.

Task: Gathering information and news from industries and companies working on the application of optics in energy, with the special focus on their interesting relevant products

Collaboration manager:

Goal: Planning collaboration coffee chats through virtual networking in small groups. The goal is to find professionals among the group members who are willing to serve as group heads and help students and early careers in the group in their profession through regular discussion.

Task: Search for the scientific background of group members, finding professionals in different categories of expertise, contact the group members and bring them more in connection and engagement

Please send your application to TGactivities@optica.org or directly to the committee chair.

EMERGING TECHNOLOGIES

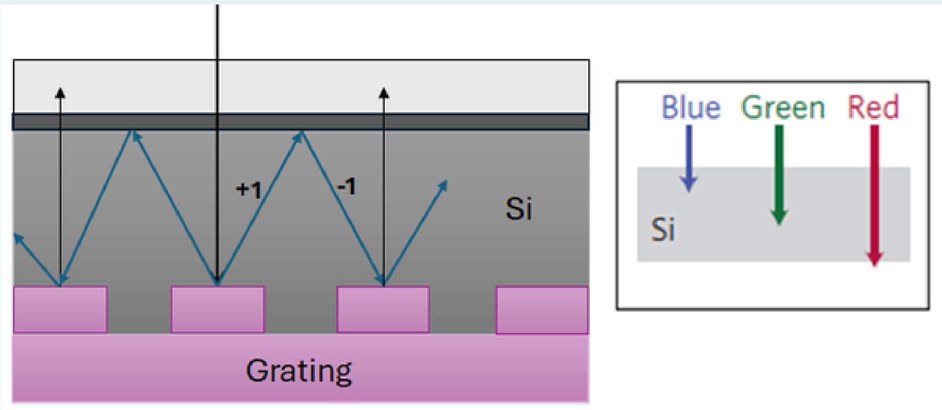
Diffraction-based light-trapping for high efficient harvesting of sunlight in solar cell

Introduction

Diffractive optical elements (DOEs) have a long history behind their design and fabrication as well as their variety of applications. Especially, the development of new lithographic techniques made the realization of master structures of subwavelength gratings possible.
The interesting application of these well-designed optical structures for increasing the efficiency of solar cells has been well-known long enough. A grating with optimized geometrical parameters integrated at the back-side of Silicon active layer can couple the incident light with a specific wavelength into a certain diffraction order. As a result, the incident light can be trapped inside the active layer by multiple reflections. This strategy has been used for increasing the absorption efficiency of silicon, as the most frequently used semiconductor material in solar cells, at higher wavelengths for which a thin-film-silicon has inefficient absorption.

References:

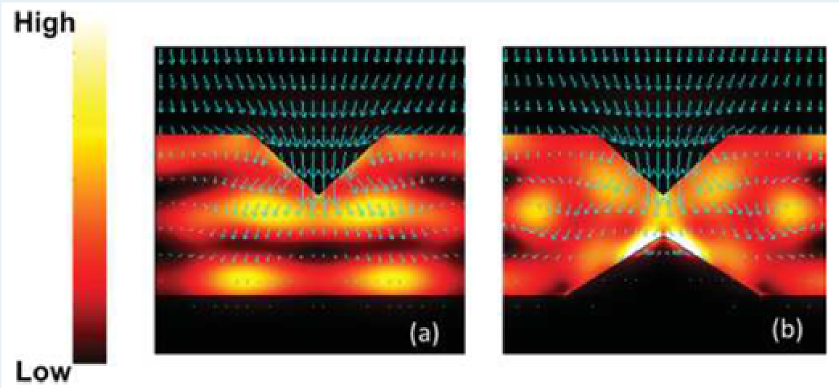
- Handbook of lasers and optics, *Springer*, ch.5
- Optoelectronics, *IntechOpen*, ch. 5
- Aimi Abbas et al., *Phsical Review B* (2012)



Schematic light trapping in a solar cell with integrated grating

Advanced designs

The light-trapping can be managed over a wider range of wavelengths using a coupled dual gratings structure. Theoretical studies have shown the complementary effect of two gratings used as front- and back-supporting layers in a solar cell. While the absorption for the shorter wavelengths (<720 nm) was enhanced via a dielectric grating used as front layer, an absorption enhancement at longer wavelengths (>750 nm) occurred with integrating a plasmonic grating as the back layer. These results show the versatility and diversity of grating design for solar cell systems.



Simulated light absorption in (a) single grating, (b) coupled grating

Correlative Confocal Raman, Photoluminescence, and Photocurrent Imaging of an Organic Solar Cell

Understanding the internal structure and charge dynamics of organic solar cells (OSCs) is crucial for enhancing their power conversion efficiency. In this highlight, a correlative imaging approach is demonstrated using confocal Raman spectroscopy, photoluminescence (PL), and photocurrent mapping to investigate the performance of an OSC. This combined methodology offers detailed spatial insights into the chemical composition, phase separation, and charge extraction efficiency within the device.

The OSC investigated was fabricated by the TEMD Research Group at London South Bank University and featured a PM6:Y6 active layer. Using the Edinburgh Instruments RM5 Confocal Raman Microscope, we conducted spatially resolved Raman and PL imaging with a 532 nm laser, alongside simultaneous photocurrent measurements. Raman imaging enabled mapping of the chemical composition, identifying characteristic vibrational bands of the PM6 polymer. Notably, regions with high Raman intensity correlated with reduced photocurrent output, indicating that local variations in polymer morphology can adversely affect charge extraction.

PL imaging provided further insights into charge carrier behaviour by visualising recombination across the cell. Areas with high PL intensity typically indicate poor charge extraction efficiency due to inhibited electron-hole separation. Spectral features at 677 nm and 883 nm confirmed emission from PM6 and Y6, respectively. A comparison of PL and photocurrent data revealed areas with significant variation in efficiency, even in the absence of visible physical defects. For instance, differences in donor-acceptor mixing, as inferred from Raman spectral ratios, explained discrepancies in PL and photocurrent responses.

Mechanical defects were also detected, with surrounding regions showing increased PL intensity and reduced current generation, further highlighting the sensitivity of these techniques to performance-limiting features.
This study highlights the utility of combining Raman, PL, and photocurrent imaging for correlative analysis of OSCs. These techniques, when used together, enable a comprehensive understanding of how chemical structure and morphology impact electronic performance. This methodology holds promise for guiding improvements in organic photovoltaic fabrication by identifying spatially dependent inefficiencies.

References:

Solak et al., RSC Adv. (2023); Nayak et al., Nat. Rev. Mater. (2019); Guo et al., Mater. Chem. Front. (2021); Fu et al., Adv. Mater. (2024); Hong et al., ACS Appl. Mater. Inter. (2023); Keshtov et al., Energy Technol. (2023); Keshtov et al., Nano Select (2020); Zhang et al., Sci. Rep. (2014).

More information: To find out more, read our Application Note, available **here**

Acknowledgements: We thank Bahattin Bademci and Dr. Tariq Sajjad (TEMD Research Group, LSBU) for providing the OSC device.

GREAT MENTORS

By Banafshe Zakeri

It was hot and I was drenched in sweat. Normal for a summer day, and could be even enjoyable when you are on the beach, but not in the lab. Well, "lab" might not be a right word because it brings in mind a facilitated room with at least some equipments. But where I was doing my experiments was not like that; a small and dark room with a table and me with one eye staring at the laser beam and the other fixed on the screen of my laptop hoping to see the light. The laser beam was supposed to be focused by my sample, a graded index lens that I was designing and fabricating back then for my master thesis. Optically, there was a very simple geometrical concept behind it, but...

"You know it's very hard to work on an experimental topic here; We don't have suitable laboratory facilities and we have very limited budget for buying materials. But since you are interested to work in the lab, I'll support you." My supervisor warned me when I insisted to pick an experimental topic for my thesis. Honestly, I didn't have any clue what "hard" could mean!

"If you have passion for designing optical elements, GRIN lens can be an interesting candidate. These microlenses have many applications. But here is the challenge; They have never been fabricated in Iran and there are no detailed information about their fabrication process. So, you are by your own to figure it out." And after a month or so, reviewing the publications on the topic, I realized that "hard" means sacrificing my whole summer in a city far away from my family, where I was studying as a master student, spending the days in the lab and nights in a room shared with friends of mine who were also sacrificing their summer for their thesis. Though I had a great supportive supervisor, he never worked with us based on a traditional cocept of mentorship when someone tells you on a daily basis what you have to do. He was a mentor who taught me to be my own mentor.

Independency for a master student is rather a new skill to learn. I learnt it because I was sure if I fail or don't get it right many times, someone is there to encourage me and help me to start over.

GREAT MENTORS

Whenever I appeared on his door with my sad face showing that it didn't work out again, I would hear: "Be patient! Patience is what you need the most when you are doing experiments." Whenever I would have come with an idea for my experiments, though he knew it won't work with the poor facilities we had, he would have carefully listened to my idea, encouraging me to never stop searching. He was not just my supervisor. He became the reason why I chose my future path in optics.

I finally saw the light after sacrificing that summer and the year after. I fabricated a laboratory prototype for a GRIN lens based on my own analytical and mathematical modeling with few facilities, no information available and months of hard work in the lab. We couldn't go further due to the limitation of time and equipments but our result got published in Applied Optics Journal and it was exciting to see my name as the first author of the paper.

Acquiring practical experiences in fabrication and optical testing, learning numerical analysis and programming, taking the first step to do research independently, all were just a small part of what I learnt from my supervisor. Being a value-driven person at work was the most important thing I learnt from him. Now, when it happens sometimes to mentor a student on a project, I remember him. A mentor who taught me with his mentorship that people are much more important than projects and results. The way you treat them and guide them through the challenges is the way they will always remember you. I learnt from him that the best mentors are those who teach you how to be your own mentor, who leave you in darkness of uncertainty because they have confidence that you will find the light, while watching you carefully to be there whenever they are needed.

For the exciting journey I started in optics that couldn't have happened if it was not because of his valuable mentorship, I'd like to thank and honor my supervisor Prof. Arash Sabatyan who has been teaching and mentoring young students in optics.

Take the chance and make your work more visible.

- **This is what I do (educational webinar)**

Present your work as a group member on OPTICA Optics for Energy TG platform

- **Highlights from group members (for the newsletter)**

Share a short summary of your recent achievement, publication, ...

- **Inspiring stories (for the newsletter)**

share your stories, experiences, and challenges with your fellow members

Coming soon:

- **Panel Discussion with Industry Experts**
- **Collaboration Coffee Chats** Strengthening your connection inside the group

Communication 💬 and Engagement

Use our social media platforms: *Facebook*, *Slack*, *LinkedIn*, and email (TGactivities@optica.org)
for discussion, information sharing, and event updates

Suggested topics for Discussion forums

Click here to join Optica Technical Group on Optics for Energy

Interdisciplinary vs cross-disiplinary research

Click here to join Optica Optics for Energy Technical Group Chat room

New materials for energy sector

Click here to join Optica Optics for Energy Technical Group

Career Focus: Improving your communication skills

A selection of your opinions on each topic will be highlighted in the next newsletter