

WHISPHERONIC SOLAR CELLS: WHISPERING-GALLERY MODE ASSISTED ENHANCEMENT IN THE POWER CONVERSION EFFICIENCY OF DSSC AND QDSSC DEVICES USING TiO₂ MICROSPHERE PHOTOANODES

IITM Technology Available for Licensing

Problem Statement

- Developments in sensitized solar cells (SSCs) require a deeper understanding of how to enhance TiO₂ photoanodes' morphology for effective light scattering, aiming to improve power conversion efficiency (PCE).
- Overcoming the energy loss due to charge recombination at nanoparticle boundaries within the TiO₂ photoanodes is a critical challenge, demanding strategies to enhance charge transfer ability and maintain high carrier mobility and lifetime.
- However, incorporating plasmonic nanoparticles as light scattering sources in TiO₂ microstructures holds promise, but the challenge lies in systematically optimizing their composition and arrangement to consistently achieve PCE above 8%, particularly in single-junction polymer solar cells.

Technology Category/ Market

Category- Photovoltaics and Advanced Solar Energy Systems

Applications- Solar Energy Generation, Large-scale Photovoltaic Installations

Industry - Renewable Energy

Market- Global photovoltaic (PV) market is estimated to reach USD 155.5 billion by 2028 at a **CAGR of 10%**.

TRL (Technology Readiness Level)

TRL - 4: Technology validated in lab scale.

Research Lab

Prof. Sudakar chandran
Dept. of Physics

Intellectual Property

- IITM IDF Ref. **1628**
- **IN 381976 - Patent Granted**

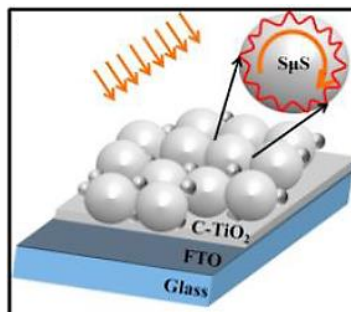


FIG. 1. Schematic picture depicts the formation of whispering gallery modes (WGMs) in TiO₂ microsphere photoanode.

Technology

- The specification reveals the presence of whispering-gallery modes (WGMs) in TiO₂ smooth microspheres, acting as dielectric resonators with multiple total internal reflections.
- A comparative study includes porous fibrous microspheres (F μ S-TiO₂) and their composites. Unlike S μ S-TiO₂, F μ S-TiO₂ and its composites do not act as spherical optical resonators due to their fibrous microstructure.
- Devices utilizing S μ S-TiO₂ demonstrate enhanced PCE in Dye-Sensitized Solar Cells (DSSC) and Quantum Dot-Sensitized Solar Cells (QDSSC). The improved efficiency is attributed to the efficient light absorption facilitated by WGMs, resulting in a PCE increase of approximately **24% in DSSC and 80-95% in QDSSC devices**.
- A composite photoanode, combining S μ S-TiO₂ and P25-TiO₂ in an **80:20 wt.% ratio**, exhibits better electrical connectivity between microspheres. This configuration creates a continuous path for the transport of charge carriers, further enhancing the PCE in solar cell devices.

CONTACT US

Dr. Dara Ajay, Head
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website:
<https://ipm.icsr.in/ipm/>

Email: smipm-icsr@icsrpis.iitm.ac.in
sm-marketing@imail.iitm.ac.in

Phone: +91-44-2257 9756/ 9719

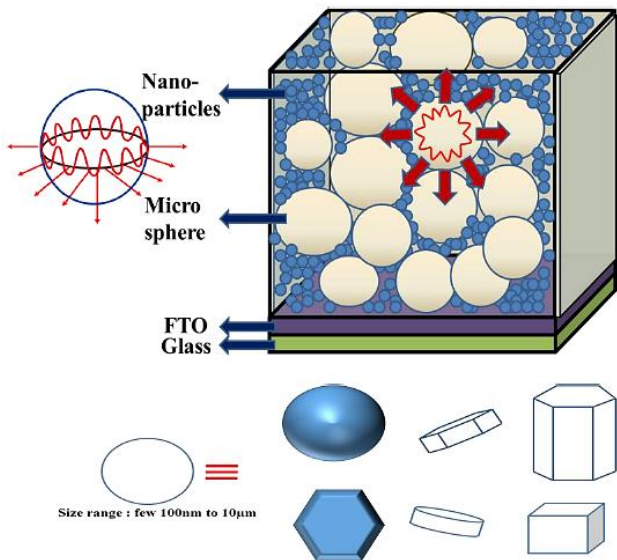


FIG. 2. Schematic representation of the "whisperonic solar cell".

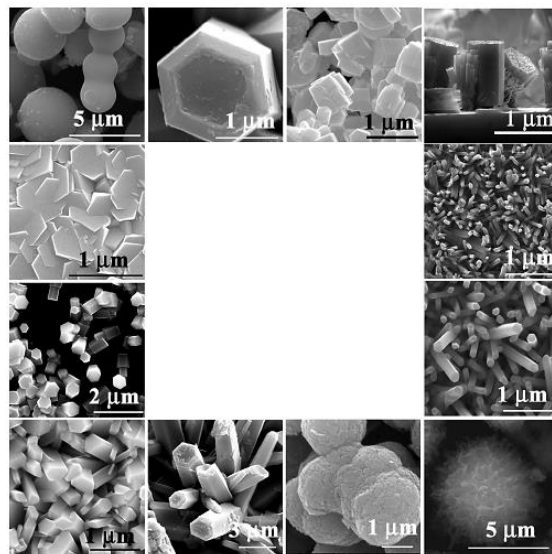


FIG. 3. SEM micrographic images of a composite comprising of mesoporous TiO₂ with micron-sized microstructures of various shapes and sizes.

Key Features / Value Proposition

1. WGM-Enhanced TiO₂ Microspheres:

- Mesoporous TiO₂ microspheres with Whispering Gallery Modes (WGMs) boost light absorption, enabling superior performance in solar cells.

2. Optimal Composite Structure:

- A composite of TiO₂ microspheres and nanocrystalline P25-TiO₂ at an 80:20 ratio maximizes power conversion efficiency in large-area sensitized solar cells.

3. Radiative Energy Transfer:

- WGMs induce resonant scattering, leading to efficient radiative energy transfer and enhanced performance in diverse solar cell devices.

4. Innovative "Whisperonic Solar Cells":

- Introducing a novel solar cell concept, "Whisperonic Solar Cells," leveraging WGMs for improved power conversion and design versatility.

5. Consistent Sensitizer Performance:

- WGM effectiveness is demonstrated across various sensitizers, ensuring reliable performance in photoanode configurations with N719 dye, CdSe QDs, and CuInS₂ QDs.

5. Market Potential for Advanced Solar Technology:

- The "whisperonic solar cells" concept presents a market-ready solution with enhanced efficiency, adaptable design, and application potential in the evolving landscape of advanced solar cell technologies.

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IITM TTO Website:

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Email: smipm-icsr@icsrpis.iitm.ac.in

sm-marketing@imail.iitm.ac.in

Phone: +91-44-2257 9756/ 9719