PV-CELLS FOR OPTICAL POWER TRANSMISSION

Optical power transmission is an elegant way to replace copper wiring with fiber optic cable for applications where conventional power supply is challenging or even impossible due to:

- the risk of short circuits and sparks
- the need for lightning protection
- electromagnetic interference
- the need for galvanic isolation
- high magnetic fields
- heavy weight of long distance cabling
- susceptibility to corrosion and moisture

Power can be transmitted in the form of light through an optical fiber or directly through air. A light source – namely a laser or an LED – generates monochromatic light. At the receiver a photovoltaic cell converts the optical power back into electricity. Consequently copper wiring can be avoided. In addition, the replacement of copper wire by optical fiber enables combination of power and data transmission into a single fiber.

Photovoltaic cells can convert monochromatic light into electricity much more efficiently than the spectrum of the solar radiation. By tuning the photovoltaic cell’s semiconductor bandgap to the specific wavelength of the light, thermalization and transmission losses are minimized. In this way, high conversion efficiencies of light into electricity over 50% have been realized.

Applications
The technology of optical power transmission is suitable for a broad range of applications, such as:

- structural health monitoring systems in wind turbines
- fuel gauges in aircraft wings
- current transducers in high voltage power lines
- implantable medical microsystems
- subscribers in optically powered networks
- monitoring units in passive optical networks (PON)

What is your application?
Our Expertise

- **Photovoltaic cell development:**
  high efficiency due to excellent material quality, advanced concepts for increased voltage output, different materials for broad range of wavelengths, front grid optimization for high power operation, customized cell size and geometry

- **Characterization:**
  spectral quantum efficiency, current-voltage characteristics at variable intensity, monochromatic light illumination, electroluminescence, photoluminescence

- **Automatic packaging:**
  mounting on transistor outline, vacuum soldering, wire bonding

- **System integration:**
  optical fiber coupling, connectors, electronic circuitry, laser driver, DC/DC converter

- **Combination with data transmission**

- **Modeling:**
  electrical, optical, thermal

- **Reliability testing:**
  degradation studies, accelerated ageing

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**Materials and Cell Concepts**

The bandgap of III-V semiconductors can be well tuned by the composition of the material. At Fraunhofer ISE, III-V materials have been used in photovoltaic cells for many years. They were originally developed for highly efficient space and terrestrial concentrator solar cells. The spectrum of available materials covers a broad range of wavelengths. In addition, advanced cell concepts are developed for highest conversion efficiencies, high power operation and increased voltage output.

Selected materials are available (with cutoff wavelength $\lambda_c$ related to the bandgap at 300 K):

- $\text{Ga}_{0.51}\text{In}_{0.49}\text{P}$  ($\lambda_c=660\text{ nm}$)
- GaAs  ($\lambda_c=870\text{ nm}$)
- $\text{Ga}_{0.83}\text{In}_{0.17}\text{As}$  ($\lambda_c=1050\text{ nm}$)
- $\text{Ga}_{0.16}\text{In}_{0.84}\text{As}_{0.31}\text{P}_{0.69}$  ($\lambda_c=1100\text{ nm}$)
- $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}$  ($\lambda_c=1680\text{ nm}$)
- GaSb  ($\lambda_c=1700\text{ nm}$)
- Ge  ($\lambda_c=1870\text{ nm}$)

Increased voltage output of the photovoltaic converter can be realized by application of advanced cell concepts:

- **Multi-junction cells:**
  vertical stacking of multiple cells interconnected by tunnel diodes

- **Multi-segment cells** (monolithic interconnected modules, MIMs):
  lateral series interconnection of several segments due to electrical separation on semi-insulating wafer

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1. Components: Optical fiber with connectors on both ends (A). Laser power converters mounted on transistor outlines (TO header) (B). Optical connector (C). Laser power converter integrated into optical connector (D).