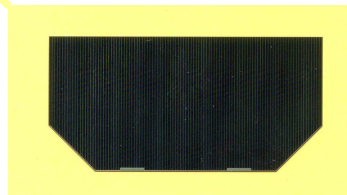
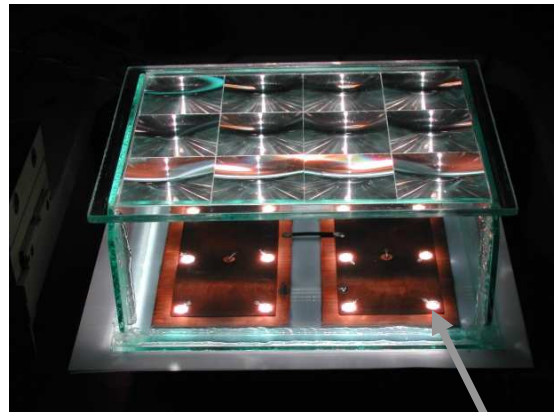
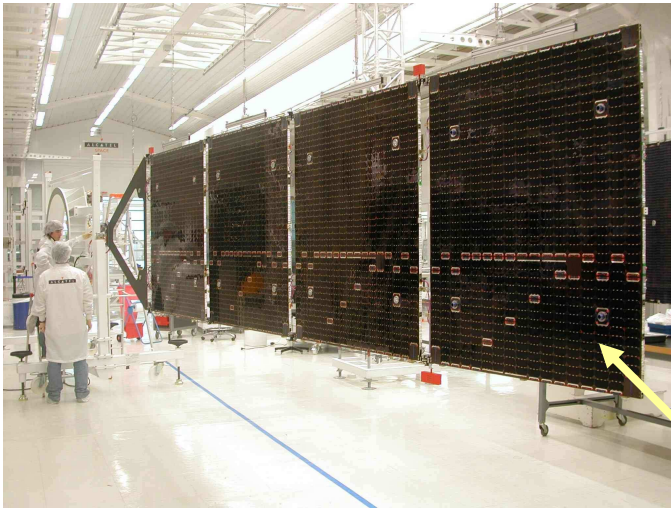


SOLAR CELLS

PRODUCTION AND DEVELOPMENT OF HIGH EFFICIENCY SOLAR CELLS FOR SPACE AND TERRESTRIAL FIELDS



HIGH EFFICIENCY SOLAR CELLS

CESI has a well-established worldwide experience in the production and development of high efficiency solar cells for the space and the terrestrial markets.

CESI can offer high technology components, development and research activities in the specific field of high efficiency solar cells based on the III-V compound semiconductors. Main assets to the manufacturing unit are the recognised test facilities of the Company the technical skills of the engineers and the well established Quality and Management System.

CESI has developed its own know how to manufacture two specific products:

- **Solar cells for space application**

- Solar cells for terrestrial concentration systems

Such knowledge is continuously upgraded and updated following the market evolution, the improvement of the production processes, and the innovations in techniques and materials.

CESI has more than 30 years experience in producing and selling high efficiency solar cells based on III-V compound semiconductors such as gallium arsenide (GaAs) and indium gallium phosphide (InGaP) deposited on germanium (Ge) substrates.

The first solar cells to be developed and manufactured in the eighties were GaAs single junctions structures.

In the most recent years, the single junctions lost a large part of their attractive, although their manufacture is still running for niche applications, in favor of the better performing InGaP/InGaAs/Ge triple junctions solar cells that CESI has

developed, optimized and qualified. This device is now in the production stage since three years and peak efficiencies close to 30% in the space environment have been obtained.

The terrestrial application of such high efficiency solar cells is economically convenient in concentrator photovoltaic systems (CPV) only. In this application, triple junction solar cells demonstrated to overcome 40% of conversion efficiency.

HERITAGE ON SPACE SOLAR CELLS

CESI is one of the few industrial suppliers of GaAs based solar cells, worldwide.

Since the first GaAs solar cells that flew in space in 1984 on board of an ESA calibration experiment, CESI solar cells powered more than 60 satellites of 18 different Countries experiencing 100% success (no failures).

Now CESI is producing fully qualified (ESA ECSS-E20-08) high efficiency InGaP/InGaAs/Ge solar cells using its proprietary structure.

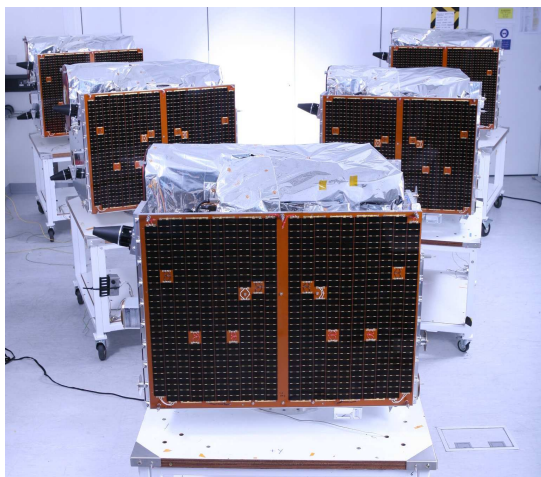
Since 2005 about 20 different satellites were powered by these solar cells.

- Modeling and characterization of solar cells for LILT applications (Low Intensity Low Temperature) and for interplanetary exploration missions (Mars, Jupiter)
- Reverse bias protection for GaAs based solar cells
- Solar cells for HIT applications (High Intensity and High Temperature) for missions close to the Sun
- Space solar cells toward 35% efficiency, using new materials, nano structures and multi junction approaches
- Thin high efficiency solar cells for flexible substrates

RECENT SATELLITES POWERED BY CESI SOLAR CELLS

Satellite	Cell type/ efficiency class	Quantity
Glonass-k	TJ*/28%	8,000
Cosmo Skymed	TJ/27%	18,000
Kanopus B	TJ /25%	2,050
N°8 DMC sat's	SJ*/19.5%	12,800
Rapid Eye	SJ/ 19.5%	9,100
Monitor E	SJ/19.0%	3,360

*TJ=Triple Junctions; SJ= Single Junctions



Rapid Eye, SSTL courtesy

The production activity for space is combined with a continuous R&D effort (about 100 scientific publications) in collaboration with National and International Space Agencies, Universities and Research Centers. Among the research programs, it is worth to mention the following:



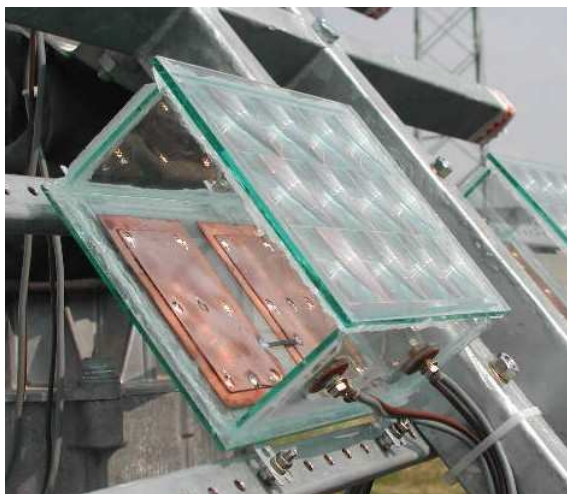
TERRESTRIAL CPV SOLAR CELLS

The technology of GaAs solar cells for concentration, has recently taken a strong boost, thanks to the impressive efficiency increase of the multijunction solar cells (>40%). Many studies show that this technology has the potential to produce energy at a cost per kWh close to the cost of traditional sources, provided that the concentration level exceeds 500 suns.

CESI experience on CPV dates back to the 80's when a few prototype systems were manufactured, for the Italian Electric Utility, using single junction solar cells.

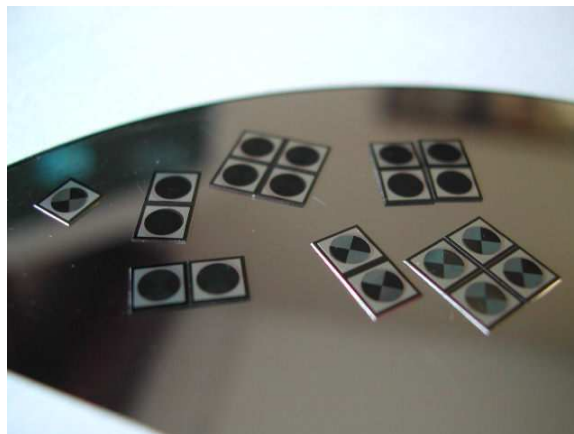
A CPV system includes several parts, in particular:

- The solar cell
- The concentration optics
- The tracking system



The solar cell is certainly the key component: its conversion efficiency, in fact, considerably weighs upon the performances of the whole system and ultimately determines the cost of the produced energy. Solar cell manufacturing is exactly where CESI expertise lies.

CESI CPV solar cells (single, dual and triple junctions) can withstand concentration factors over 1000 suns. The solar cell design can be tailored for point focus and dense array receivers. CESI developed more than 30 different mask designs and is available for custom requests.



CESI CPV solar cells are by default optimised for AM1.5D spectrum, where they achieve state of the art efficiencies as high as 38%. Nevertheless, to increase the power generation at module level, CESI provides its expertise to tune the solar cell structure to the spectral response of the concentrating optics.

CESI R&D efforts are aimed to further increase the solar cell performances for standard and spectrum splitting CPV systems with the aim to overcome the 40% efficiency at solar cell level and the 30% efficiency at module level. To reach these challenging targets, our research activities are carried out in close contact with system manufacturers.

CESI is also actively involved in working groups at international level for the standards definition



WHAT WE CAN OFFER

CESI provides the following services in both space and terrestrial market fields:

- Supply of space solar cells
- Supply of concentrator solar cells
- Customisation of solar cells design
- Supply of epitaxial wafers for solar cell manufacturing
- Training and licensing of GaAs PV technology
- Development of advanced technology solutions in PV, including modeling and computer codes

OUR MAJOR CUSTOMERS**SPACE AGENCIES**

- Italian Space Agency
- European Space Agency

SPACE INDUSTRIES

- Selex Galileo
- OJSC RPE Kvant
- SSTL
- ATSB
- SRTIIE

UNIVERSITIES**CPV INDUSTRIES**

CESI

Via Rubattino 54
I-20134 Milano - Italy
Tel +39 02 21251
Fax +39 02 21255440
e-mail: info@cesi.it
www.cesi.it