



# **Solar technology of flexible Cu(In,Ga)Se<sub>2</sub> (CIGS) thin film**

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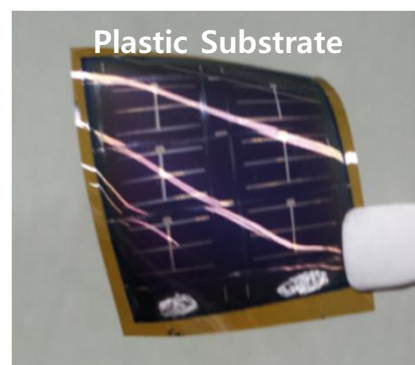
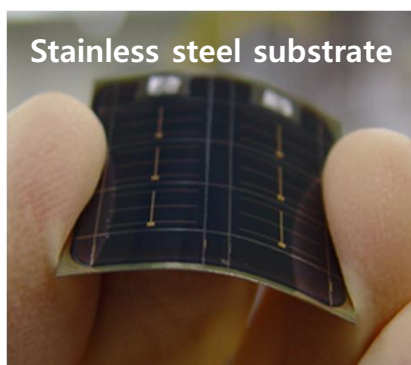
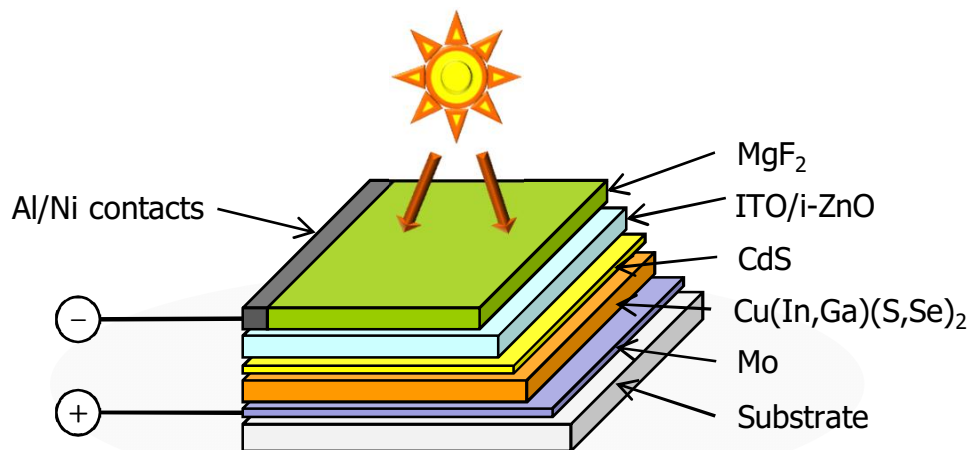
# TECHNOLOGY BRIEF

## Solar technology of flexible Cu(In,Ga)Se<sub>2</sub> (CIGS) thin film

### ■ Technology Overview

Cu(In, Ga)Se<sub>2</sub> (CIGS) compound semiconductor has a direct-transition-type energy bandgap. Also, because of its highest light absorption coefficient among all semiconductors, it is possible to manufacture a high-efficiency solar cell with a thin film of 1 ~ 2  $\mu\text{m}$  thickness.

The thin film solar cell with metal or plastic substrate instead of traditional glass substrate has a high output ratio.



### □ Keywords

Flexible, CIGS, Thin film, Sunlight(Solar energy)

### □ TRL 5

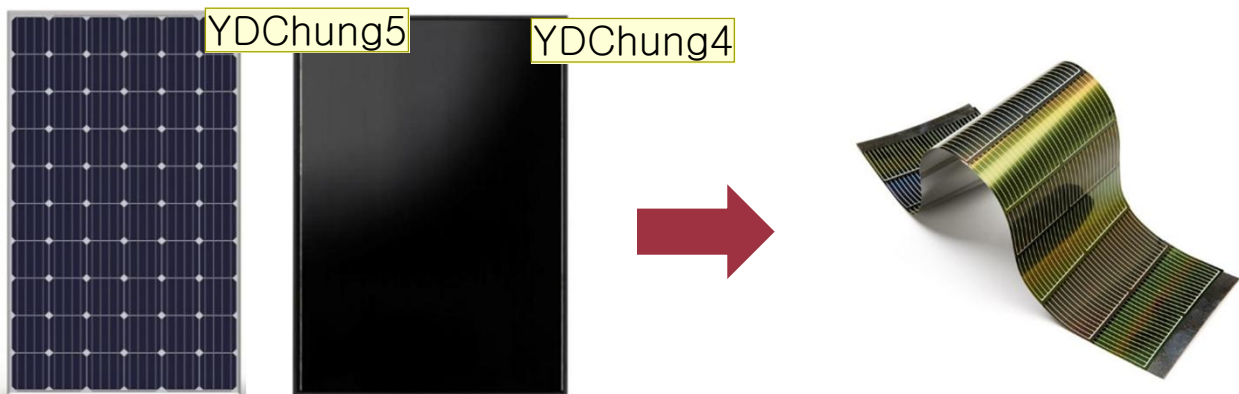
| Technology Classification Code |                  |          |
|--------------------------------|------------------|----------|
| Sector                         | Sub Sector       | Industry |
| Energy • Resources             | Renewable Energy | Sunlight |

# TECHNOLOGY BRIEF

## Solar technology of flexible Cu(In,Ga)Se<sub>2</sub> (CIGS) thin film

### ■ Technology Description

- A flexible thin film solar cell using flexible metal substrate or plastic substrate can be bent or curved so that it can be modified in various forms. On top of that, it is light and has a very excellent portability.



### ■ Application Fields



- It is expected to create new value in industrial fields such as IT industry, transportation including electric vehicles, outdoor goods, etc.

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YDChung4 <http://www.sonopsolar.co.za/product/solar-frontier-165w/>  
정용덕, 2016-08-16

YDChung5 <http://www.yinglisolar.com/en/products/monocrystalline/ylm-60-cell-series-1/>  
정용덕, 2016-08-16

## ▣ Outstanding Features

|                   | Nominal output(W) | Open circuit voltage (V) | Short circuit current (A) | Dimension (mm)    | Weight (kg) | Specific Power (W/kg) |
|-------------------|-------------------|--------------------------|---------------------------|-------------------|-------------|-----------------------|
| Glass substrate   | 165               | 110                      | 2.20                      | 977 x 1257 x 35   | 20.0        | 8.25                  |
| Metal substrate   | 62                | 28                       | 4.2                       | 1333 x 762 x 2.5  | 1.41        | 43.97                 |
| Plastic substrate | 115               | 24.1                     | 7.61                      | 800 x 1320 x 11.5 | 1.40        | 82.14                 |

### ▶ Limitation of existing technology

- Specific power of a thin-film solar cell using conventional glass substrate is up to 8.25W/kg.

### ▶ Excellence of the technology

- Specific power of a thin-film solar cell using the metal substrate is about 44W / kg, and a thin film solar cell using a plastic substrate has specific power of approximately 82W/kg.
- In the case of plastic substrate, it is about 13 times higher than the thin-film solar cell using glass substrate.
- Flexible thin-film solar cells are suitable for aircraft and car that require light weight, or architecture that do not need to consider the load.

## ▣ IPR Status

Korean patent: 1 article registered

| No. | Country | Application Number (date) | Status     | Title  |
|-----|---------|---------------------------|------------|--|
| 1   | US      | 8987037 (2015.03.24)      | registered | Methods of manufacturing a solar cell  |
| 2   | US      | 8852991 (2014.10.07)      | registered | Methods of manufacturing solar cell  |
| 3   | US      | 8637765 (2014.01.28)      | registered | Single junction type CIGS thin film solar cell and method for manufacturing the thin film solar cell |

## ■ Technology Trend

According to the industrialization trend of flexible CIGS thin film solar cell, the field can be divided into two opposing sides.

One is United States and Europe based on the advanced technology and the other is China which tries to overcome the technical handicap with its capital.



## □ Korea

- Samsung SDI has reached the stage of switching the technology obtained from  $300 \times 300 \text{ mm}^2$  sub-module to fifth-generation mass production technology in 2013, but withdrew its commercialization in late 2014.
- Hyundai Heavy Industries was proceeding joint venture with Avancis from Germany, but discontinued its commercialization in 2013.
- LG Innotek planned production in early 2012, but finally stopped its commercialization.
- SK Innovation invested in Heliovolt from US and planned commercialization, but withdrew its business in 2014.
- Daiyangmetal promoted the commercialization of flexible CIGS thin film solar cell using stainless steel substrate for the first time in Korea. But it gave up the business due to difficulty in securing mass production technology.
- Avaco had strategic investments in Stion from US and focused on equipment development, but the commercialization is opaque due to performance aggravation of Stion.

## □ Global

- Global Solar of US had produced flexible CIGS thin-film solar cells based on stainless steel from 2008, and was acquired by Hanergy in China in 2013.
- Ascent Solar of US is producing flexible CIGS thin-film solar cells which are based on polyimide.
- SoloPower of US is using stainless steel to produce flexible CIGS thin film solar cell with non-vacuum deposition method.
- Flisom of Switzerland had facilities of 15MW class in 2013. It is now developing a mass production process for mass production of low-cost flexible solar cell module through R2R process.
- Solarion of Germany have founded a 20 MW-scale plant, but after its 2013 restructuring, is now performing limited production.
- Hanergy of China has acquired Solibro in Germany, Miasole in US, and Global Solar in US. It is planning to increase the CIGS thin film solar cell production capacity up to 3 GW.

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YDChung6 <http://www.globalsolar.com/>  
정용덕, 2016-08-16

YDChung7 <http://www.ascentsolar.com/>  
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YDChung8 <http://solopower.com/>  
정용덕, 2016-08-16

YDChung9 <http://www.flisom.com/>  
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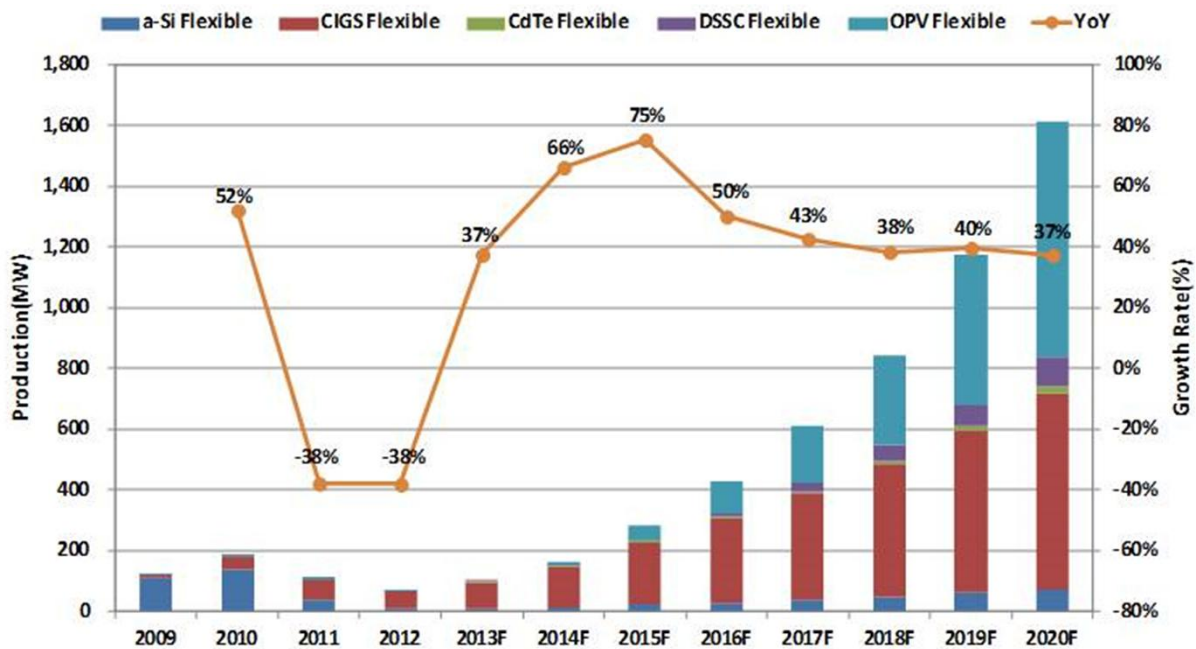
YDChung10 <http://www.solarion.de/main.html>  
정용덕, 2016-08-16

YDChung11 <http://midsummer.se/>  
정용덕, 2016-08-16

## Market Trend

Amorphous Si solar cell was the market leader of flexible solar cells till 2009. Since 2010, new CIGS and other flexible solar cells companies have joined the market, making it have a full-out growth.

The market will show high growth rates in the future due to expansion of the solar market, and is expected to show a production level of 1.6 GW in 2020.



※ Source: SNE Research, 2013, "Application technology and market prospect of the next-generation flexible thin-film solar cell (2009–2020)"

## Market Leaders

### World-leading company status

- Global Solar Energy, Ascent Solar, SoloPower, Flisom, Solarion

### Domestic leading company status

- Dasstech, Iijin Materials, SolarFLEX

## Technology Demand

### Application

Flexible solar module business, flexible solar equipment business, solar power business

### Industry

Mobile power supply, electric cars, airplanes, building integrated solar cells



## ■ Scope of Technology Transfer

- Selection and characterization techniques of flexible substrate
- Formation technique of rear electrode
- Formation technique of simultaneous-evaporation absorber
- Supply technology of Alkali metal
- Formation technique of dry buffer layer
- Formation technology of window layer
- Module production technology

## ■ Applications and Effects



### ► Expected applications

- Building Applied Photovoltaics (BAPV)
- Building Integrated Photovoltaics (BIPV)
- Vehicle Integrated Photovoltaics (VIPV)
- Power of portable devices such as military, laptop, cell phone

### ► Expected effect

- The solar cell is not merely of the power generation system. It can be merged as a key component of various products. Consequently, it is expected to become a growth engine of the new markets and technologies.
- When using a low-cost roll-to-roll process, energy recovery period can be lessened due to low input of production energy.

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YDChung1 <http://www.ascentsolar.com/markets/>  
정용덕, 2016-08-16

YDChung2 <http://www.ascentsolar.com/comsumer-offg/>  
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YDChung3 <http://www.ascentsolar.com/dandm/>  
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