

The researches on thin film semiconductor solar cells in China

NuoFu Chen

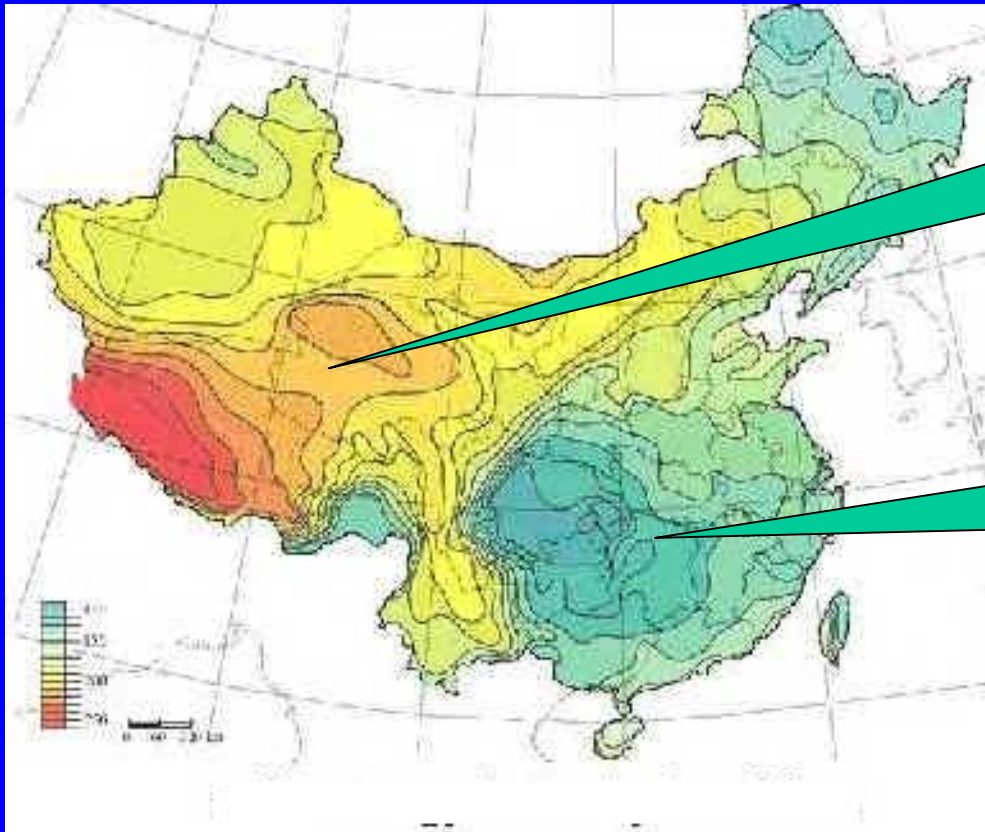
**Key Laboratory of Semiconductor Materials Science,
Institute of Semiconductors, Chinese Academy of
Sciences, Beijing 100083, China**

Outline

- **Introduction**
- **III-V photovoltaic material and devices**
- **silicon photovoltaic material and devices**

Introduction

- **Solar Energy Resources in China**

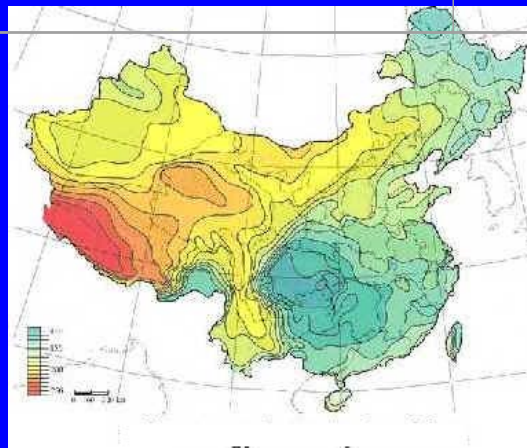


West
Abundant
sunshine

East
deficient
sunshine

Solar Energy Resources in China

Color	Area	Annual Value (KWh/ m²)	Daily Value (KWh/m²)
Red	Westest	≥ 1860	≥ 5.1
Orange	Mid westest	1500 – 1860	4.1 – 5.1
Yellow	West & Middle	1200 – 1500	3.3 – 4.1
Blue	East	< 1200	< 3.3



•Un-electrified Villages and Households

Province	Un-electrified Villages	Un-electrified Households
23	29 thousand	7 million

If 300Wp per household

The potential market will be 2100MWp

- **Other potential market in China**

- **Solar battery recharge station**
- **Solar street and yard lightening**
- **Solar-powered automobiles**
- **Solar-powered boats**

➤ **Demand for solar power**
More than 10 BWp

III-V photovoltaic material and devices

★ GaAs based solar cells

➤ Merit:

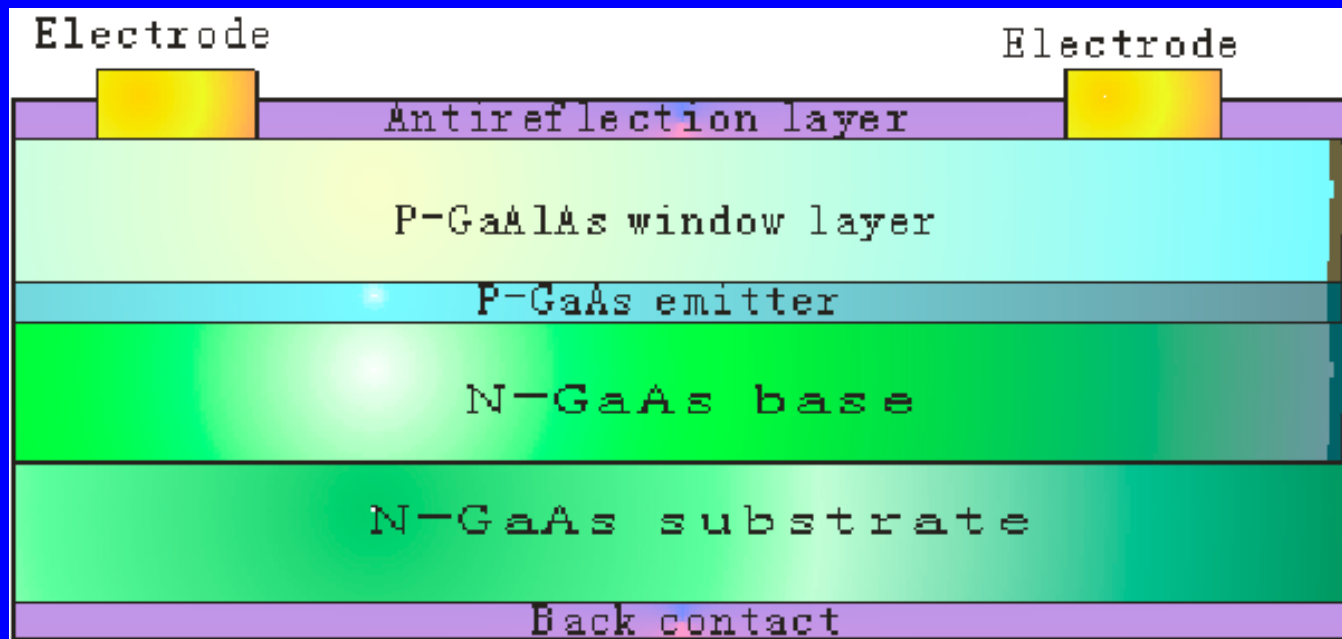
- High efficiency

- Tolerance to cosmic ray

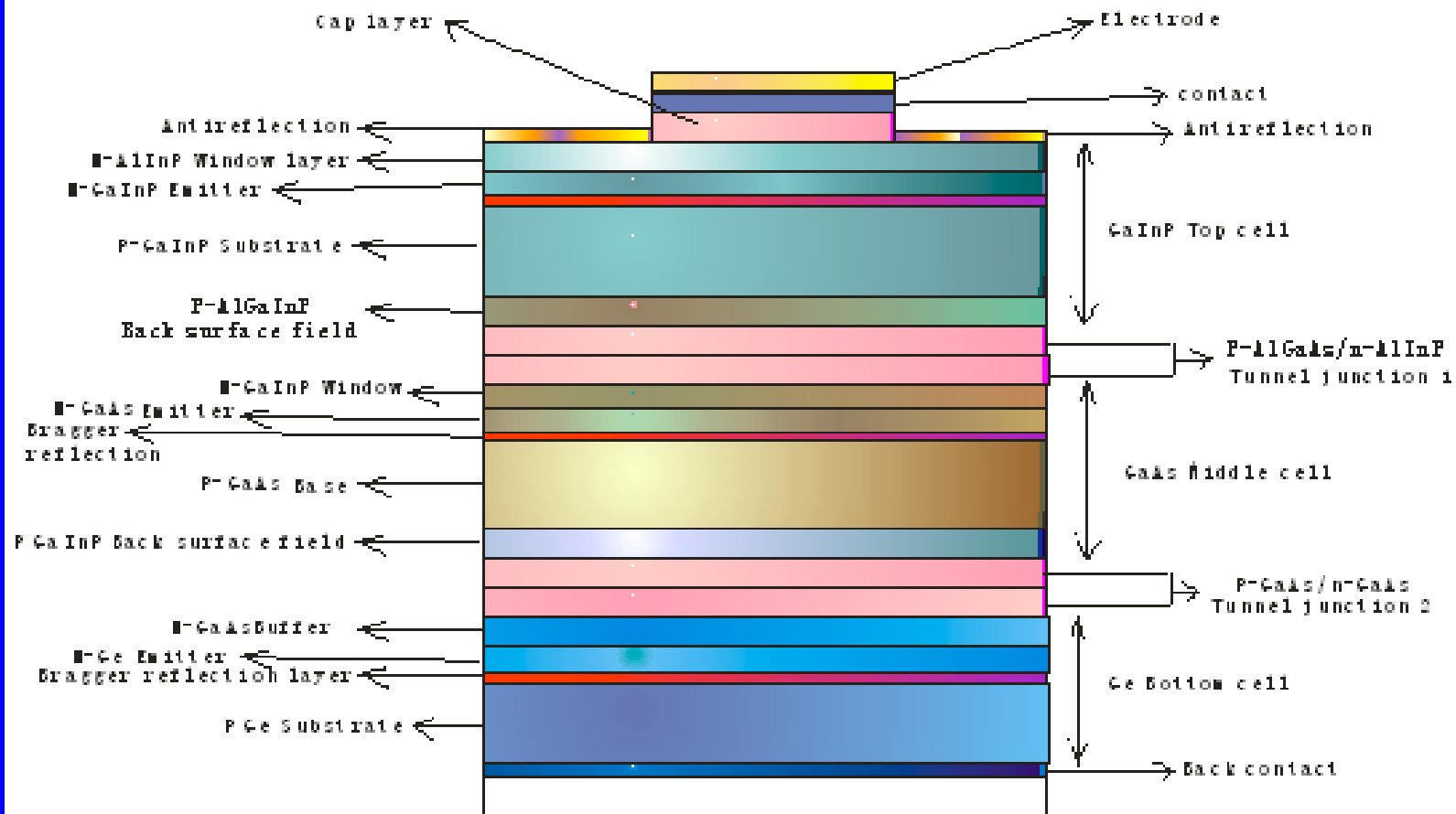
➤ Disadvantage:

- Expensive cost

➤ Application: Space craft



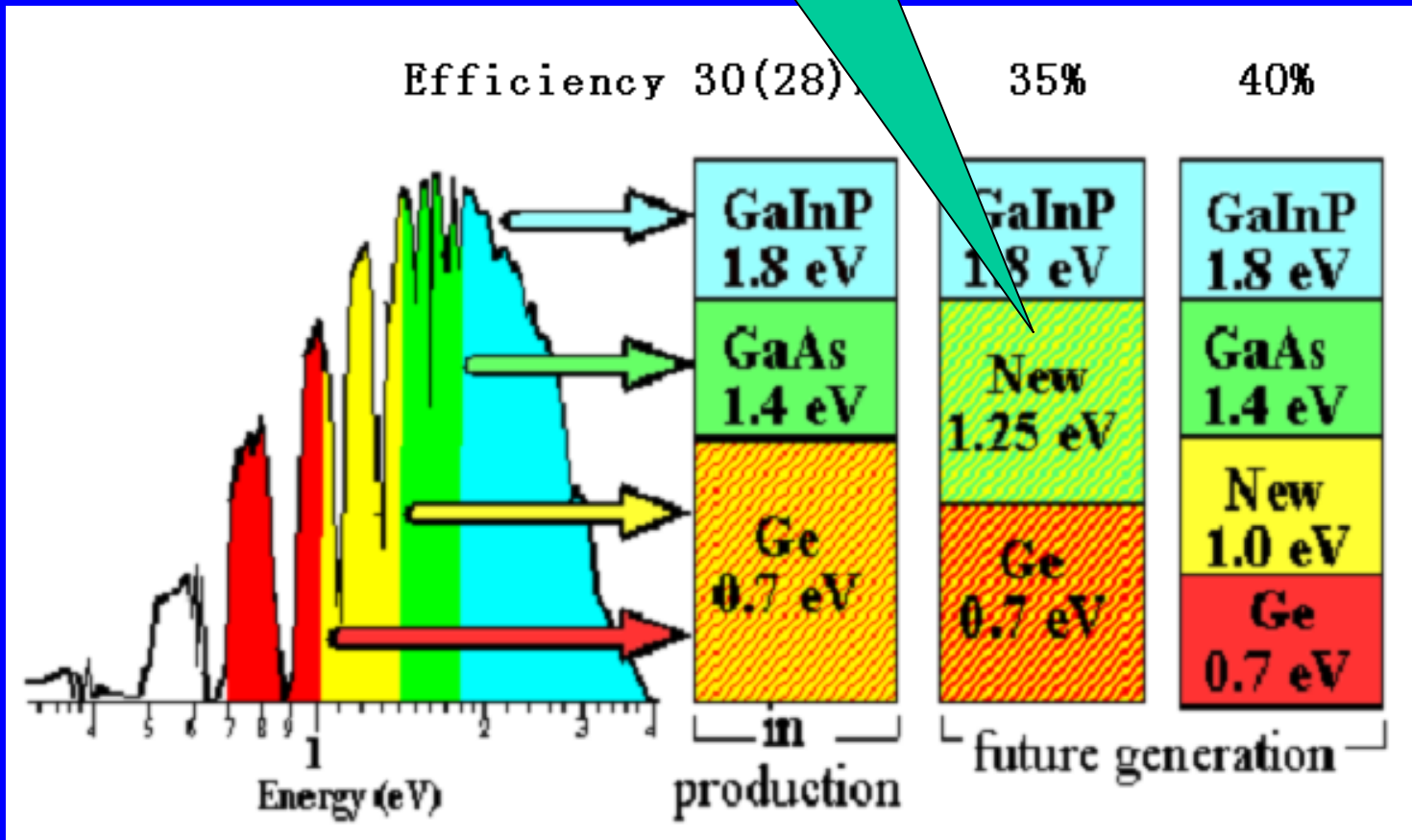
The structure schematic of single-junction GaAs solar cell



The structure schematic of triple-junction $Ga_{0.5}In_{0.5}P/GaAs/Ge$ solar cell

Present efficiency of GaAs based solar cell

- Single junction GaAs solar cell
AM1.5, 25 °C: 21.9% (2×2 cm²)
- Triple junction GaInP/GaAs/Ge solar cell
AM1.5, 25 °C: 28% (2×2 cm²)

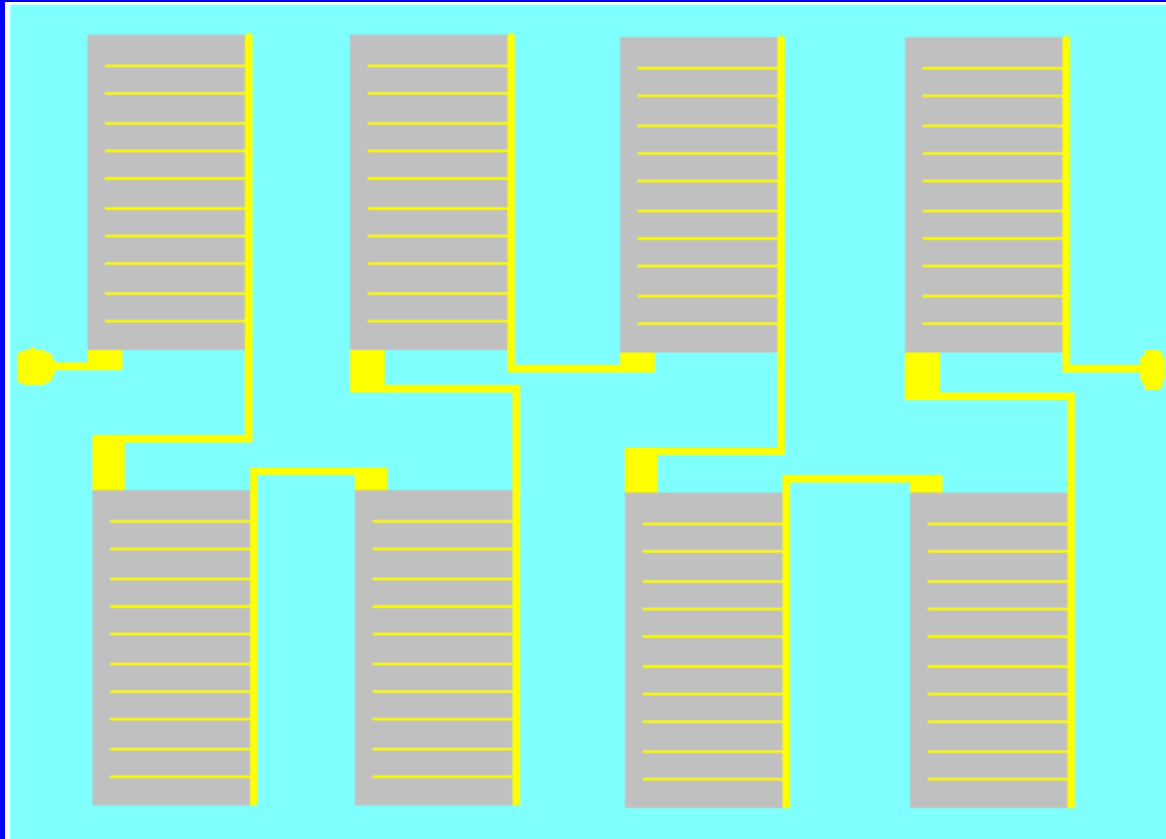


Future multi-junction solar cell

Application of GaAs solar cells

- **Single junction GaAs/GaAs & GaAs/Ge solar cells have been used on satellites**
- **The triple junction solar cell
GaInP/GaAs/Ge
was used in Chinese small satellite last year**

★ Integrated solar cell chip



Supply power to micro electronic
mechanical system (MEMS)

★ **Concept research:**

InGaN based solar cells

Eg: (InN) 0.72eV ——— 3.39 (GaN)

➤ **Prospect: Whole solar spectra cell**

Multi-junction structure

$\text{In}_{x_1}\text{Ga}_{1-x_1}\text{N} / \text{In}_{x_2}\text{Ga}_{1-x_2}\text{N} / \dots / \text{In}_{x_n}\text{Ga}_{1-x_n}\text{N}$

➤ **Problems:**

➤ **Substrate**

➤ **Lattice mismatch**

Silicon photovoltaic material and devices

- **Mono-crystalline Si solar cell**
- **Poly-crystalline Si solar cell**
- **Amorphous silicon (a-Si) solar cell**

Crystalline Si solar cell

Highest Efficiency

Category	Highest Efficiency (%)	Size (cm²)
Monocrystalline Silicon Cell	20.4 14-15	2 × 2 10×10
Polycrystalline Silicon Cell	14.5 12-13	2×2 10×10
GaAs solar cell	21.9%	2×2

Application of crystalline Si solar cell

- **Monocrystalline Si solar cell**
 - **Space crafts**
- **Polycrystalline Si solar cell**
 - **Daily life**
 - **Street & yard lightening**
 - **Power station**
 - **House roof**

Amorphous Si solar cell

- **A-Si:H films for photovoltaic solar cells**
- **Solar Cells on Flexible Substrates**

•A-Si:H films for photovoltaic solar cells

	V_{oc} (V)	J_{sc} (mA/cm ²)	FF	Eff (%)
Init.	0.915	13.89	0.716	9.10
Stab.	0.935	13.45	0.681	8.56

Solar Cells on Flexible Substrates

The defect density of a-Si:H is minimum at a growth temperature of 200 - 250 °C ($\sim 10^{15} \text{ cm}^{-3}$).

Substrate Material Requirement:

⇒ Stable at 200 - 250 °C.

⇒ Undeformed

Impurity-free

Stainless Steel foil
Plastics (Polyimide)

Application of Flexible Solar Cells

- Lightweight- ideal for space Applications
 - ◆ *With the highest power/weight*
- Potential low cost technologies on the solar cells

Future Directions – Flexible Solar Cells

- **Develop low-temperature technique to get texturing on flexible substrates**
- **Roll-to-roll process allows for ease of integration – power everywhere!**
- **Doublejunction a-Si solar cells to reduce instability**
- **Explore alternatives: microcrystalline Si**

Thank you very much

谢 谢