Renewable Energy Laboratories at the Colorado School of Mines
Second Generation Panels for Solar Power

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Long-term Energy Future: Solar

- Current total global energy generation: 13 TW
- Projected increase by 2050: 30 TW
- Requires construction of two 1-GW power plants per day!
- The Jim Bridger plant (WY) is ~ 2.4 GW
- Theoretical: $1.2 \times 10^5$ TW solar energy potential
- Practical: $\approx 600 - 1500$ TW solar energy potential (Depending on land fraction etc.)

Nathan Lewis, 2003
Solar Photovoltaic Electricity

PV can supply all electricity for the U.S. using this area (100x100 mi.) in the SW

OR by using a distributed* approach using available areas throughout the U.S. Average area per State would be 17x17 miles.

Area required for PV systems is 0.40% of the continental U.S.

*Vacant land, parking lots, building integrated, etc.
PV Technologies - Generations

Cost ($/m²) vs Efficiency (%)

- $0.10/W
- $0.25/W
- $0.50/W
- $1.00/W
- $3.00/W

I  II  III

Colorado Energy Research Institute
Colorado School of Mines
Colorado Solar Energy Companies

ITN Energy (Global Solar)
PrimeStar Solar
Ascent Solar
MVSystems
ADA Technologies
Luca Technologies
Industrial Solar Technology
PV Technologies

MVSystems flexible Si solar cell
Third Generation PV: A Short Digression

• “Third generation” (thin-film) technologies may come on line:
  • Nano-technologies (quantum dots and wires)
  • Inorganic-organic hybrids
  • Thin-film crystalline silicon
  • Large area multi-junctions
  • ???
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Intermediate Band Solar Cells

MOCVD Growth of InGaAs/GaAs QD arrays on (113)B GaAs substrates for intermediate band solar cells

- QD arrays are being grown to test concept of intermediate band solar cell proposed by A. Martí and A. Luque

(311)B 50 period InGaAs/GaAs QD superlattice plan-view TEM

- Chains of quantum dots along <110>

A. Norman, M. Romero, and M. Al-Jassim, (NREL), A. Luque, A. Martí, Spain
Summary

• Several “second generation” (thin-film) technologies exist:
  • Amorphous Silicon
  • Cadmium Telluride
  • Copper Indium Diselenide
  • Copper Indium Gallium Sulfide

• Other Technologies May Come On Line:
  • Organic Materials
  • Thin-Film Crystalline Silicon
CSM Renewable Energy Focus Areas

• 35 years of excellence!
• Photovoltaics
• Wind Generators
• Fuel Cells
• Energy Storage
• Controls, Grid Optimization, Power Systems Engineering
• Storage of Radioactive Waste
• Geothermal, Hydrogen Research
Colorado Can Grow
World-class Photovoltaic and Fuel Cell Industries

- Local Cell Developers
- Local Equipment Manufacturers
- Materials and Service Providers
- Finance & Management Consultants
- World-Class Universities
- R&D Laboratories (NREL)
Colorado Collaboratory

• Recent Developments
  – Salazar letter to legislature and Governor recommending Renewable Energy Institute among NREL, CSM, CU, CSU; being discussed in legislature.
  – State funding ($2 M/year) to match collaboratory research proposals.
  – One proposal already submitted.
  – Organizational structure being discussed at “highest levels”.
Renewable Energy Initiatives
Fiscal Year 2005-2006

• Renewable Energy Working Group
• “Colorado Collaboratory”
• Joint Institute (CSM and NREL)
• Joint Appointments (CSM and NREL)
• Collaboratory Proposal to Basic Energy Sciences (DOE)
• XCEL Solar Test Facility (SoCom)
• Solar America Initiative
• CERI Regional Facility (GRL)