

N85-32422

# SENSITIVITY ANALYSIS OF HIGH-EFFICIENCY SILICON SOLAR-CELL DESIGN PARAMETERS

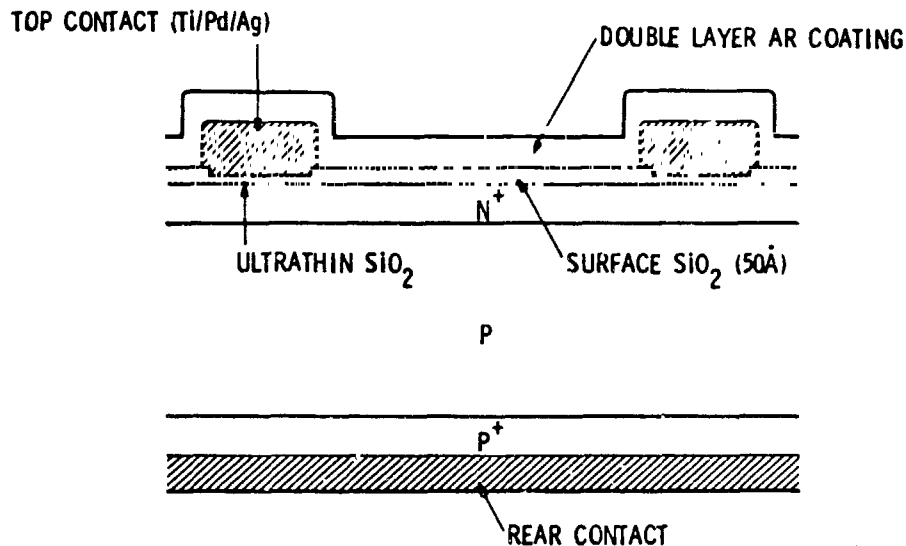
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## Outline

- EXPERIMENTAL VS SIMULATION RESULTS
- DOPING PROFILE MODIFICATIONS
- SENSITIVITIES OF CRITICAL PARAMETERS
- CONCLUSIONS

## Cross Section of the Silicon Solar Cell Considered for Sensitivity Analysis

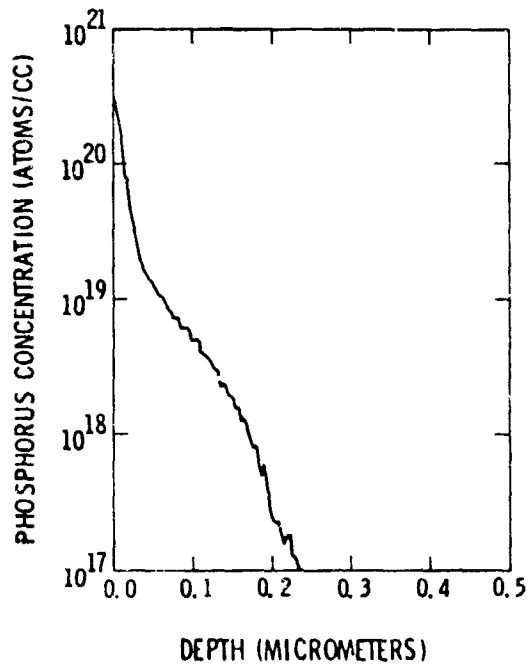


REF: IEEE TRANSACTIONS ON ELECTRON DEVICES, VOL ED-31, NO. 5, MAY 1984

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# HIGH-EFFICIENCY SILICON SOLAR CELL RESEARCH

## Doping Profile of the Silicon Solar Cell



## Solar-Cell Parameters

- BULK RESISTIVITY -  $0.2 \Omega\text{-cm}$  ( $2.0 \times 10^{17}/\text{cm}^3$ , B)
- MINORITY-CARRIER LIFETIME -  $20.0 \mu\text{sec}$
- CELL THICKNESS -  $280.0 \mu\text{m}$
- FRONT JUNCTION DEPTH -  $0.23 \mu\text{m}$
- FRONT SURFACE DOPING CONC. -  $2.8 \times 10^{20}/\text{cm}^3$  (PHOS)
- FRONT SURFACE RECOMBINATION VELOCITY -  $1,000 \text{ cm/sec}$
- BACK SURFACE CONTACT - ohmic

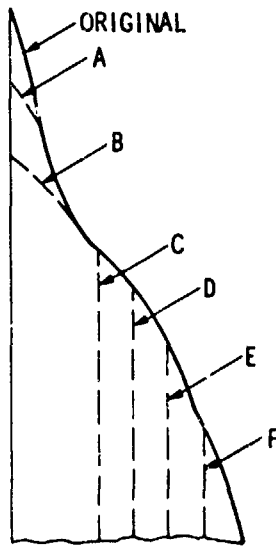
Experimental vs Simulation Results

TYPE	V <sub>oc</sub> (mV)	I <sub>sc</sub> (mA)	FF	EFFICIENCY (%)
EXPERIMENTAL*	641.11	35.48	0.8220	18.70
SIMULATION (X)	638.76	35.08	0.8334	18.53

• MARTIN GREEN'S MINP CELL

(X) SOLAR CELL ANALYSIS PROGRAM IN 1 DIMENSION (SCAP1D)  
DEVELOPED BY PURDUE UNIVERSITY FOR SANDIA LABORATORY

Doping Profile Modification



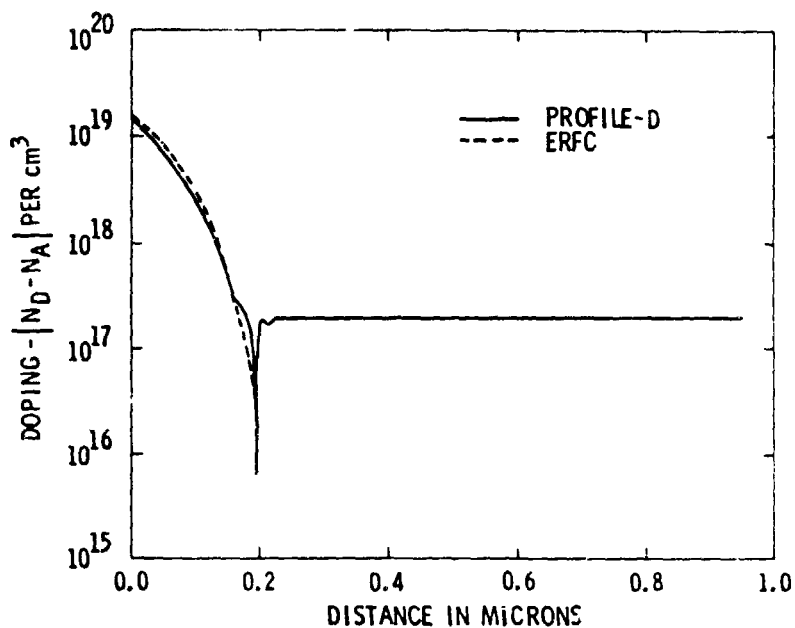
TYPE	FRONT SURFACE CONC.	FRONT JUNCTION DEPTH	EFFICIENCY (%)
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ORIGINAL	$2.8 \times 10^{20}$	0.23 $\mu\text{m}$	18.53
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A	$5.0 \times 10^{19}$	0.23 $\mu\text{m}$	19.21
B	$2.0 \times 10^{19}$	0.23 $\mu\text{m}$	19.24

C	$1.8 \times 10^{19}$	0.21 $\mu\text{m}$	19.27
D	$1.6 \times 10^{19}$	0.19 $\mu\text{m}$	19.29
E	$1.1 \times 10^{19}$	0.17 $\mu\text{m}$	19.28
F	$7.5 \times 10^{18}$	0.15 $\mu\text{m}$	19.27

Complementary Error Function vs Profile-D

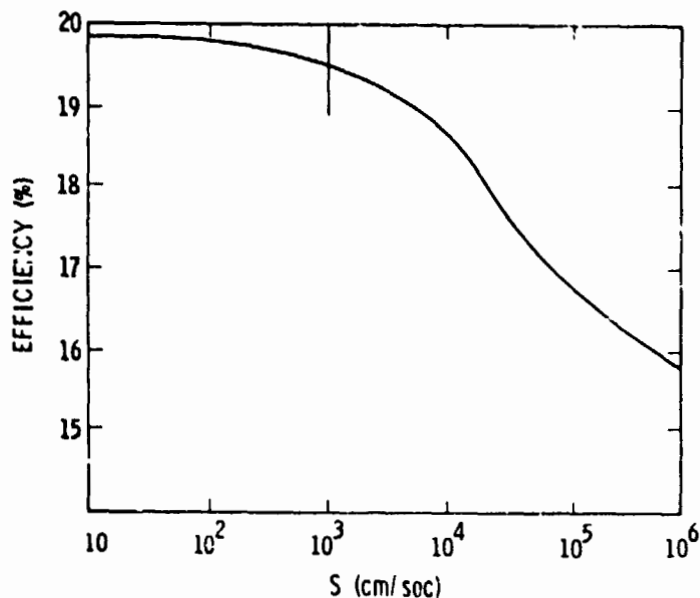


Sensitivity Analysis

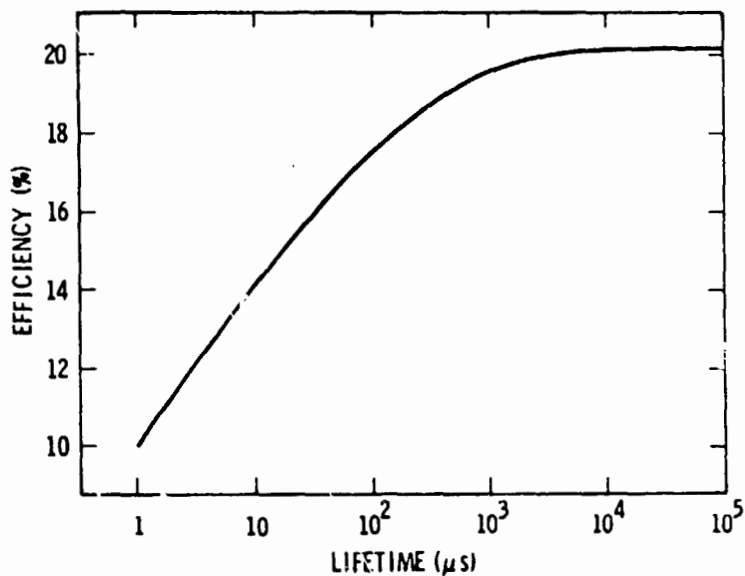
CRITICAL PARAMETERS

- SURFACE RECOMBINATION VELOCITY
- MINORITY-CARRIER LIFETIME
- CELL THICKNESS
- BACK SURFACE FIELD

Front-Surface Recombination Velocity Sensitivity

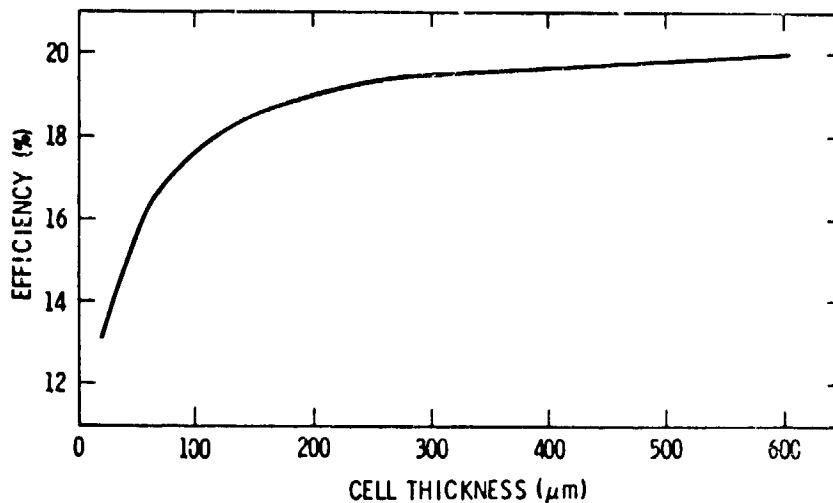


Minority-Carrier Lifetime Sensitivity



# HIGH-EFFICIENCY SILICON SOLAR CELL RESEARCH

## Cell Thickness Sensitivity



## Effect of Back-Surface Field

BACK SURFACE CONC.	BACK JUNCTION DEPTH (μm)	EFFICIENCY (%)
$2 \times 10^{17}$	0	19.55
	10	19.55
$1 \times 10^{18}$	2	19.57
	5	19.59
	10	19.63
$1 \times 10^{19}$	2	19.61
	5	19.68
	10	19.76
$1 \times 10^{20}$	2	19.67
	5	19.74
	10	19.78

# HIGH-EFFICIENCY SILICON SOLAR CELL RESEARCH

## Conclusions

- THERE IS GOOD AGREEMENT BETWEEN EXPERIMENTAL AND SIMULATION RESULTS
- SHEET MATERIAL QUALITY IMPROVEMENT IS NEEDED FOR HIGH EFFICIENCY CELLS
- 20% CELL OF THIS DESIGN IS FEASIBLE WITH 10 ms BULK LIFETIME MATERIAL
- FOR ACHIEVING EFFICIENCIES HIGHER THAN 20% NEW CELL DESIGNS INCLUDING THIN CELLS WITH LIGHT TRAPPING AND BACK SURFACE FIELD SHOULD BE CONSIDERED