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EXCIMER LASER ANNEALING FOR FABRICATION OF LOW-COST SOLAR CELLS

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Program Goal

TO DETERMINE IF PULSED EXCIMER LASER ANNEALING (PELA) IS COST EFFECTIVE COMPARED TO BASELINE PROCESS.

BASELINE PROCESS	LASER PROCESS
CLEAN	CLEAN
DRY	DRY
DIFFUSE JUNCTION	
ALUMINUM BSF	ION IMPLANT
CLEAN	LASER ANNEAL
PRINT Ag BACK	PRINT Ag BACK
PRINT Ag FRONT	PRINT Ag FRONT
LASER CUT	LASER CUT
TEST AND SORT	TEST AND SORT

Objectives

- BUILD AN EXCIMER LASER PULSED ANNEAL APPARATUS
- DEVELOP ANNEAL PROCESSING FOR HIGH EFFICIENCY CELLS
- FABRICATE 300 SOLAR CELLS
- PERFORM ECONOMIC ANALYSIS

Laser-Annealed AR-Coated Cells

CELL	LOT	ρ (Ω cm)	V_{oc} (mV)	J_{sc} (mA/cm^2)	FF (%)	Eff (%)
4615-4d	SW-27	0.34	616	31.2	80.2	15.4
4615-8e	WA70055	0.31	614	31.7	79.9	15.6
4615-12d	WA70055	0.17	617	30.4	80.2	15.0
4615-16a	WA20820	0.34	616	31.2	80.0	15.4
4615-20b	WA20979	2.2	592	32.0	79.5	15.1

NOTES: INSOLATION WAS SIMULATED AM1, 100mW/cm^2. T=28°C. A=4cm^2.

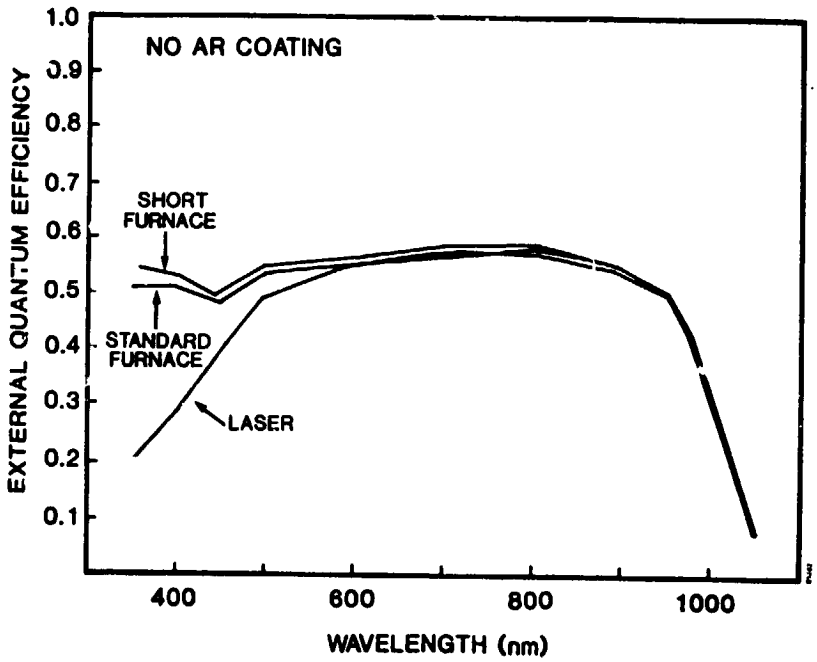
Advantages and Disadvantages of Laser Annealing

- RAPID DRY PROCESSING
- NO HEATING OF THE WAFER
- TEXTURED WAFERS DIFFICULT TO ANNEAL
- NOT COMPATIBLE WITH SiO_2 PASSIVATION

Best-Cell Comparison of Laser Annealing With Furnace Annealing (No AR Coatings)

CELL	ANNEAL	V_{oc} (mV)	J_{sc} (mA/cm^2)	FF (%)	Eff (%)
4615-4d	LASER	607	22.6	79.5	10.9
4524-13e	SHORT FURNACE	612	23.6	81.4	11.8
4524-9c	STANDARD FURNACE	615	23.9	82.0	12.0

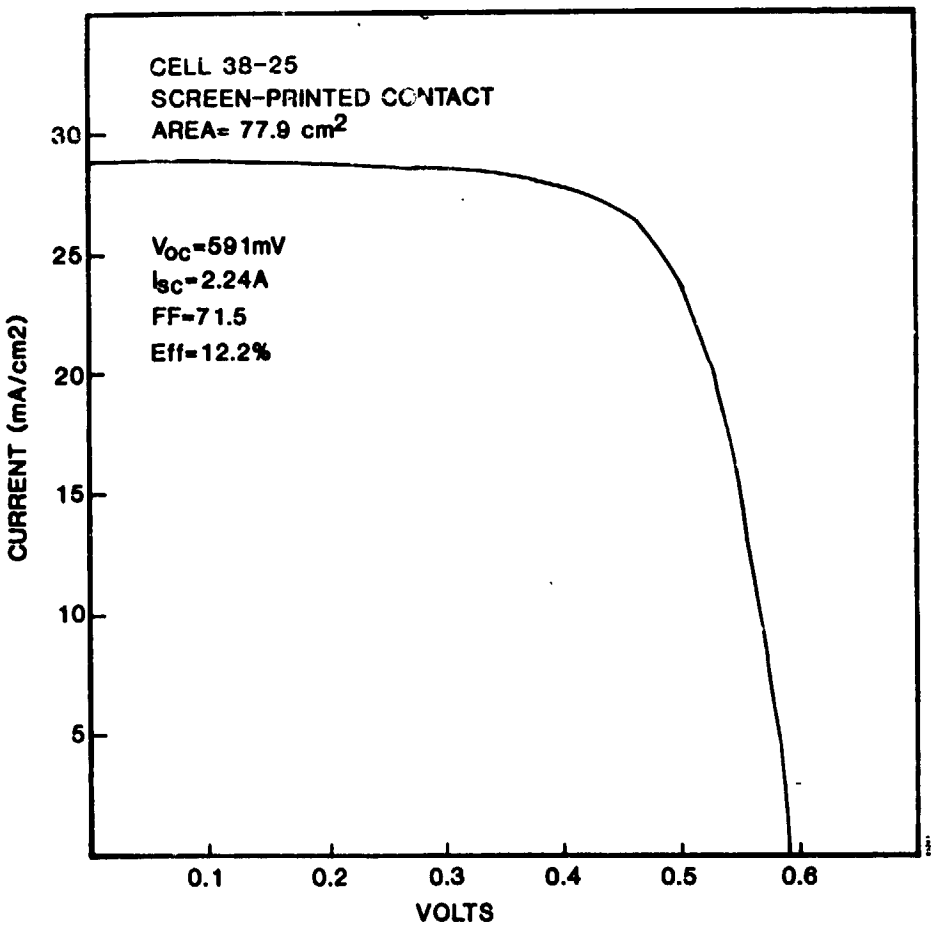
NOTES: INSOLATION WAS SIMULATED AM1. 100 mW/cm^2. T=28°C. A=4cm^2.



Large-Area AR-Coated Solar Cells

NO. OF CELLS	METALLIZATION	ANNEAL	V_{OC} (mV)	J_{SC} (mA/cm^2)	FF (%)	Eff (%)
7	PRINTED	LASER	589	27.1	72.8	11.5
7	PRINTED	FURNACE	590	28.9	71.5	12.1
4	EVAPORATED	LASER	590	28.9	77.9	13.3
5	EVAPORATED	FURNACE	591	30.8	77.4	14.1

NOTES: AREA OF EVAPORATED CELLS IS 53cm^2.
AREA OF SCREEN-PRINTED CELLS IS 77.9cm^2.
INSOLATION WAS AM1,100mW/cm^2. T=28°C



Excimer-Laser-Annealed Solar Cells

CONTACT	NO. OF CELLS	V_{oc} (mV)	J_{sc} (mA/cm^2)	FF (%)	Eff (%)	Effx1.4 (%)
EVAPORATED (53cm^2)	92	580 (3)	21.2 (0.3)	78.1 (0.6)	9.6 (0.2)	13.4 (0.3)
PRINTED (77.9cm^2)	25	580 (2)	19.9 (0.3)	71.0 (2.0)	8.2 (0.3)	11.5 (0.4)

NOTES: INSOLATION WAS AM1, 100mW/cm^2, T=28°C.

Summary of Economic Analysis

PROCESS	COST-PER-WAFER (1985$)
ION IMPLANT PHOSPHORUS (SPI-ION 1000)	0.18
TUBE FURNACE ANNEAL	0.07
BELT FURNACE ANNEAL	0.035
EXCIMER LASER	0.05

1MW/SHIFT, 3 SHIFTS/DAY, 90% YIELD.

Principal Findings

(1) EXCIMER LASER ANNEAL IS SATISFACTORY WHEN APPLIED TO POLISHED WAFERS. ANNEALING OF TEXTURED WAFERS REQUIRES FURTHER WORK.

(2) THE 50 WATT EXCIMER LASER IS CAPABLE OF HIGH THROUGHPUT PROCESSING.

(3) LASER UNIFORMITY IS SUFFICIENT.

(4) SCREEN-PRINTED CONTACTS CAN BE APPLIED TO EXCIMER-LASER-ANNEALED WAFERS.

(5) ANALYSIS INDICATES THAT THE LASER MUST PRODUCE BETTER CELLS THAN THE FURNACE TO BE ECONOMICALLY COMPETITIVE.