N85-32432

PULSED EXCIMER LASER PROCESSING FOR COST-EFFECTIVE SOLAR CELLS

ARCO SOLAR, INC.

D. Wong

CONTRACT TITLE: ADAPT PULSED EXCIMER LASER PROCESSING FOR COST EFFECTIVE SOLAR CELLS

CONTRACT NO: 956831

GOAL: TO DEMONSTRATE THE COST EFFECTIVE FEASIBILITY OF FABRICATING 16% EFFICIENT SOLAR CELLS ON 125 MM DIAMETER CZ WAFER USING PULSED EXCIMER LASER FOR JUNCTION FORMATION, SURFACE PASSIVATION, AND FRONT METALLIZATION.

Texturing

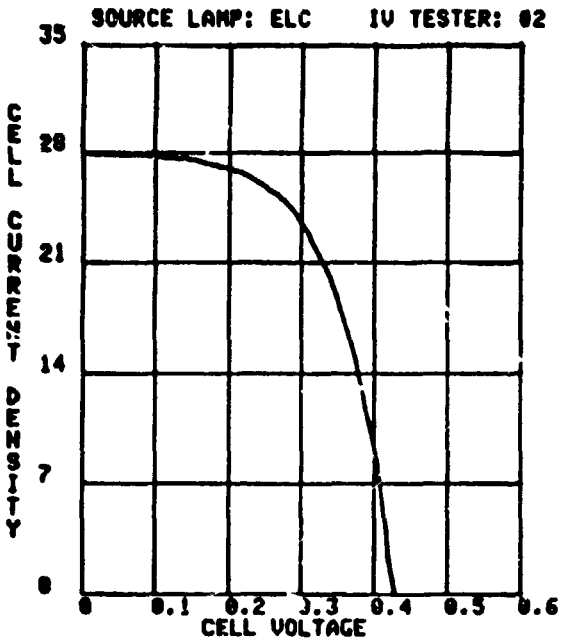
0.4 J/CM^2 (70% OVERLAP) SUFFICIENT TO MELT THE SURFACE.

CELLS WERE SHUNTED. 650°C, 30 MIN. FURNACE ANNEALING MOST OFTEN IMPROVED THE V_{OC}.

$\langle \eta \rangle$ ~6.5% BEFORE 650°C

$\langle \eta \rangle$ ~11% AFTER 650°C

EXCESSIVE SURFACE MELTING IS BELIEVED TO LIMIT CELL EFFICIENCY.



LIGHT IV AT 25C
OPERATOR:DW
CELL:L5B, CONTROL#1
Date/time:09-JUL-84 10:53:07

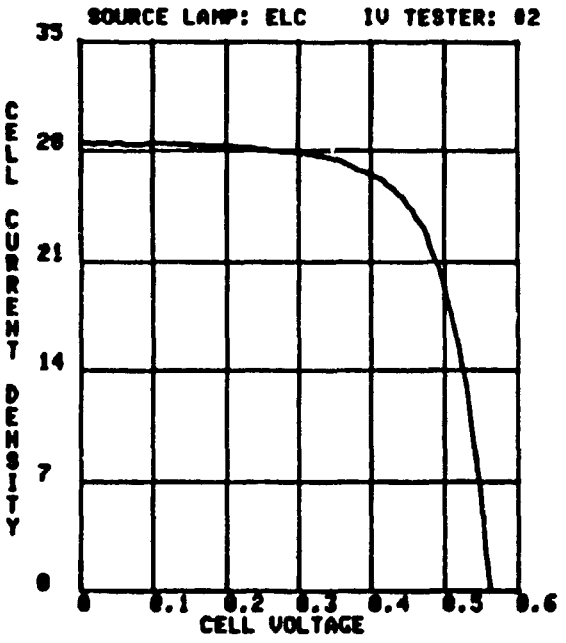
AREA: 4.00 (sq.cm)

Isc: 0.112 (amps)
Jsc: 28.00 (ma/sq)
Voc: 0.427 (volts)

Ipm: 0.093 (amps)
Jpm: 23.24 (ma/sq)
Vpm: 0.385 (volts)

Pm: 0.028 (watts)
Cff: 59.21 %
Eff: 7.09 %

RUN 5 B, ENERGY/= 0.4J/CM2, OVERLAP 50%
SINTERED



LIGHT IV AT 25C
OPERATOR:DW
CELL:L5B ANNEALED 3
Date/time:27-JUN-84 09:58:28

AREA: 4.00 (sq.cm)

Isc: 0.114 (amps)
Jsc: 28.54 (ma/sq)
Voc: 0.563 (volts)

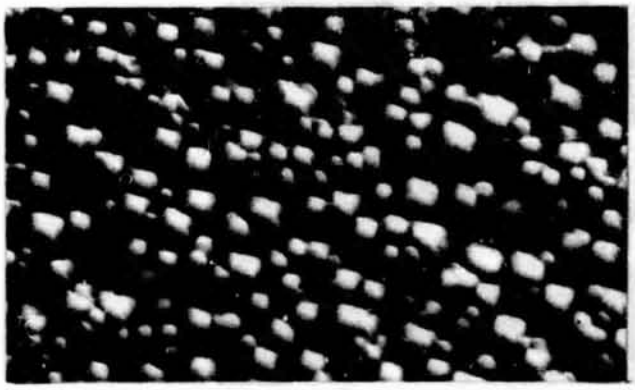
Ipm: 0.100 (amps)
Jpm: 25.09 (ma/sq)
Vpm: 0.442 (volts)

Pm: 0.044 (watts)
Cff: 69.10 %
Eff: 11.10 %

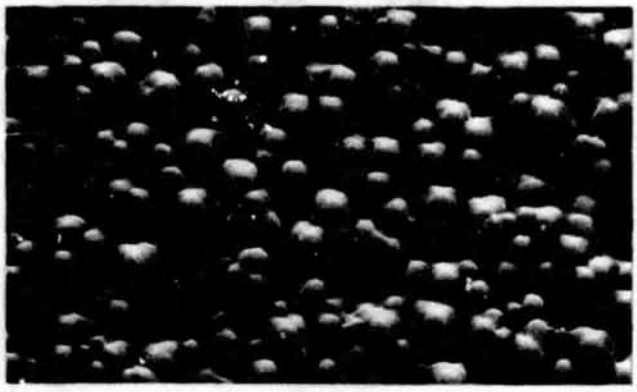
RUN 5 B, ENERGY =0.4J/CM2, OVERLAP 50%
ANNEALED THERMALLY @ 650 C 30 MIN.
NO SINTERED

Threshold Energy Density for Textured Surface to Start Melting

Surface Melting on Textured Surface Due to Laser Annealing at Different Laser Energy

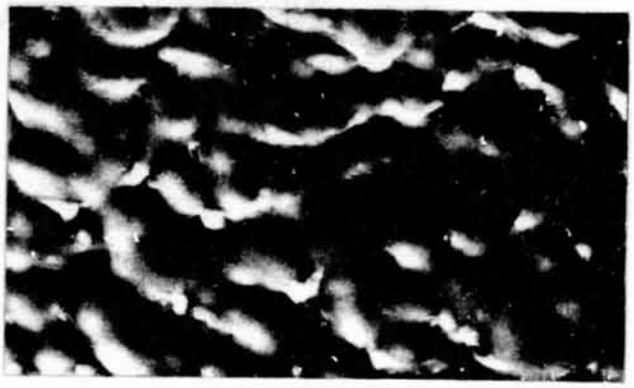


Ø.4 J/CM^2



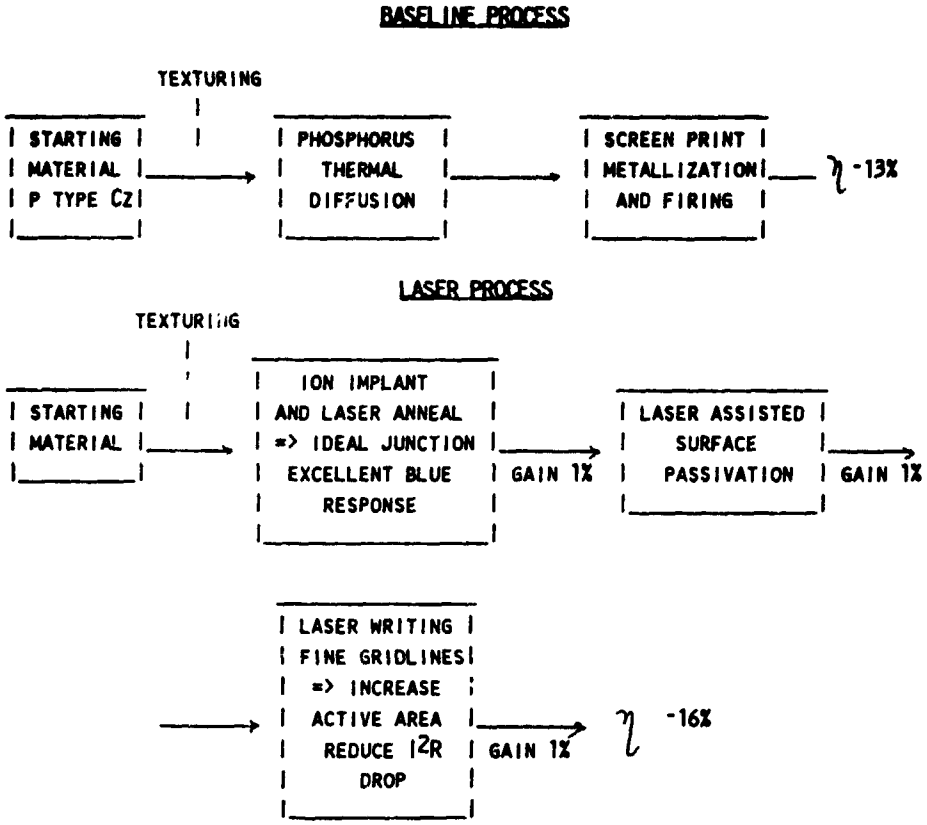
Ø.7 J/CM^2

Ø.9-1.2 J/CM^2

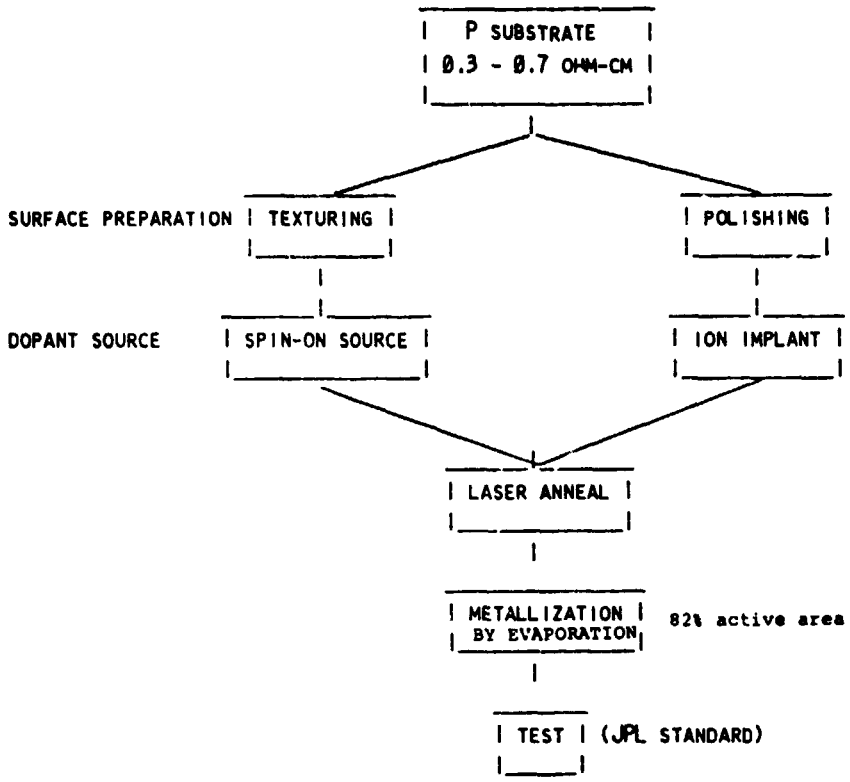


2 J/CM^2

Comparison of Baseline Process With Proposed Excimer Laser Process



Experimental



Polished Wafer (p-Type Cz) Ion Implant $^{31}P^{+}$

(J/CM^2)	BEAM SIZE (MM X MM)	OVERLAP (%)	PULSE (NS)	IMPLANT (KEV)	DOSAGE (1×10^{15})	RHO (OHM/SQ) APPROX	η %
0.7	1.1 x 0.8	40	6	10	5	31	7.3
0.7	1.1 x 0.8	40	6	10	1	90	4.2
1.3	0.95 x 0.95	70	25	5	2.5	50	7.1
1.3	0.75 x 0.6	20	25	5	1	70	8.9
1.3	9.0 x 7.5	20	80	5	2.5	50	8.4
1.45	9.6 x 8.3	12	90	5	1	90 - 100	9.3
1.55	8.9 x 7.5	12	90	5	1	90 - 100	9.3
2.0	7.5 x 6.5	12	90	5	1	90 - 100	9.4

Laser Energy Density

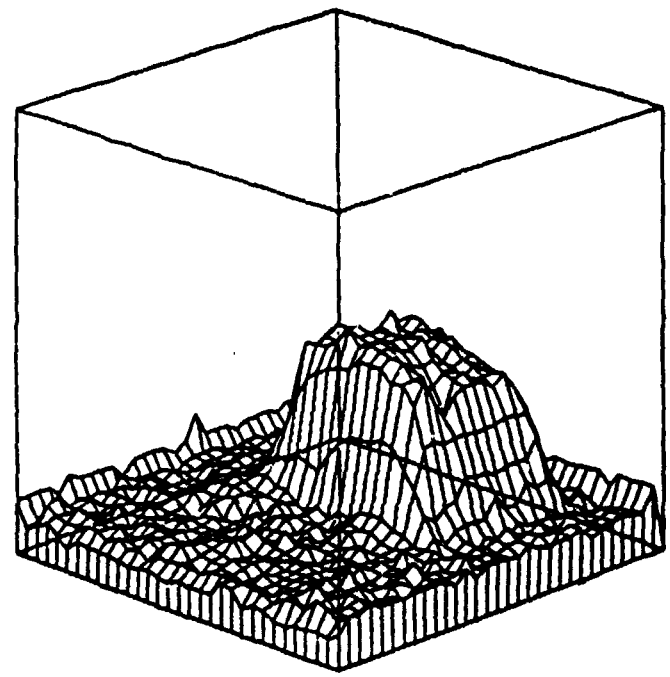
LASER ENERGY DENSITY FROM 1.45 J/CM^2 TO 2 J/CM^2 YIELDED SIMILAR RESULTS IN CELL EFFICIENCY FROM THE SAME IMPLANT. HOWEVER, SURFACE DAMAGE STARTED TO BE OBSERVED AT 2 J/CM^2.

Overlap, %

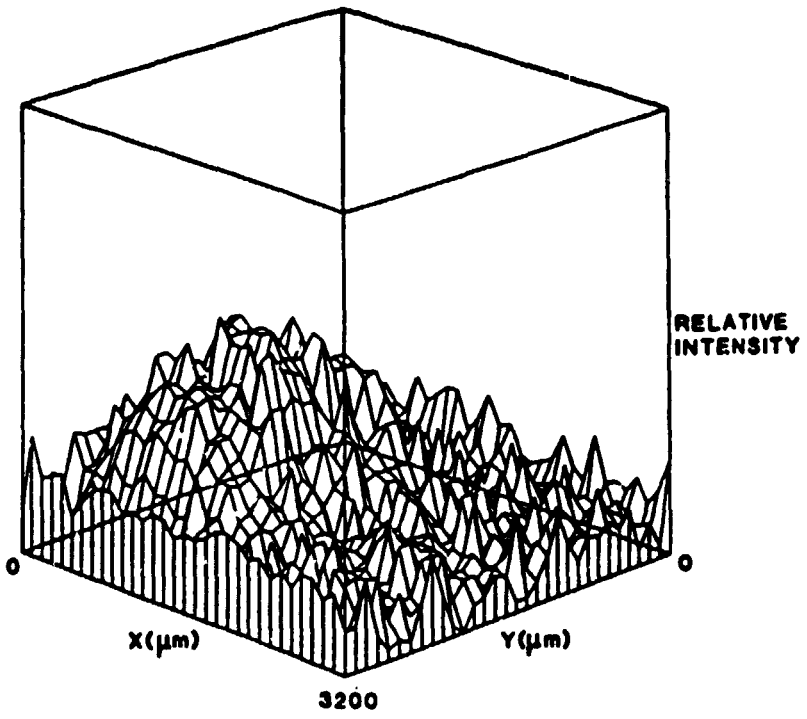
NECESSARY FOR COMPENSATING BEAM NONUNIFORMITY. HOWEVER, FOR HIGHLY NONUNIFORM BEAM, OVERLAP WOULD PRODUCE SEVERE SURFACE DAMAGES.

MORE UNIFORM LASER WITH LARGER BEAM SIZE REDUCES OVERLAP REQUIREMENT ——> HIGHER CELL EFFICIENCY.

Kaleidoscope Beam Profile (MSNW Inc.)



Profile of Excimer Output Beam (MSNW Inc.)



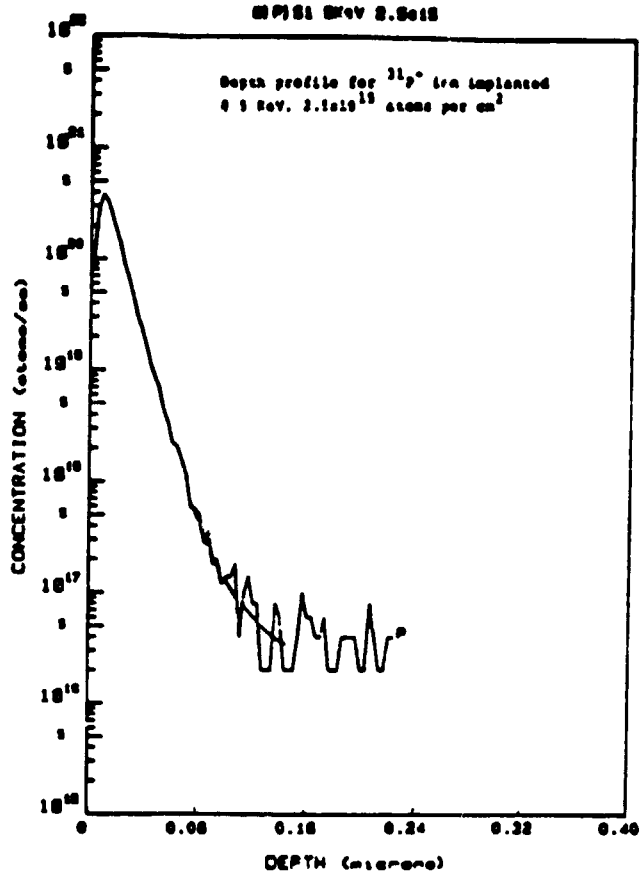
Ion Implant

5 KeV $^{31}P^{+}$ CHANNELED TO ABOUT 0.16 - 0.22 μM WHICH REQUIRES LASER ENERGY AT LEAST 1.6 J/CM^2 - 1.8 J/CM^2 TO REMOVE LATTICE DAMAGES COMPLETELY.

Indirect Proof

Cz WAFER WITH THERMAL N+ DEPOSITION (838°C 10 MIN) FOLLOWED BY LASER ASSISTED DIFFUSION AT 1.25 J/CM^2 (12% O.L.) YIELDED ALMOST IDENTICAL IN ELECTRICAL PERFORMANCE AS THE THERMALLY DIFFUSED CELL (≥10%).

Depth Profile



SIMS Depth Profile for $^{31}P^+$ Ion Implanted at 5 keV, 2.5 x 10^{15} Atom per cm^2. Substrate Resistivity ~0.3 ohms-cm Boron Doped.

Summary on Junction Formation

IDEAL JUNCTION REQUIRES

(I) SHALLOW ION IMPLANT TO MINIMIZE LASER ENERGY DENSITY FOR COMPLETE LATTICE DAMAGE REMOVAL.

(II) UNIFORM LASER BEAM THAT REQUIRES LESS THAN 5% OVERLAP.

Plans for Next Quarter

(I) IMPROVE LASER UNIFORMITY

(II) INVESTIGATE THE CAPABILITY OF 1 KEV ION IMPLANTATION BY GLOW DISCHARGE TECHNIQUE.

(III) COMPLETE GAS CELL SYSTEM AND INITIATE EXPERIMENT ON LASER ASSISTED SURFACE PASSIVATION AND GRIDLINE WRITING.