

PROCESSING

N87-16422

# LASER-ASSISTED SOLAR CELL METALLIZATION PROCESSING

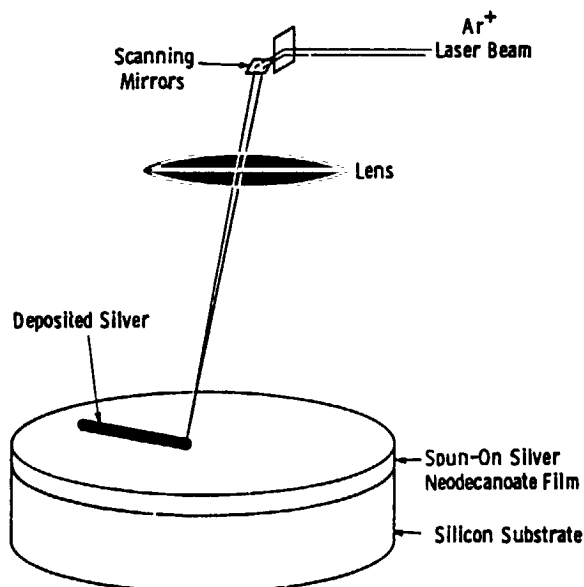
WESTINGHOUSE ELECTRIC CORPORATION  
RESEARCH AND DEVELOPMENT CENTER

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## Topics

- **Basic Concept**
- **Linewidth**
- **Cells Fabricated Without Masks**
- **Alternative Metals for Improved Adherence**

## Laser Pyrolysis of Spun-On Metallo-Organic Film



Sample Base Temperature 75°C

Focussed Laser Spot Decomposes Spun-On Film

Silver Metallization Patterns are Formed by Direct-Writing

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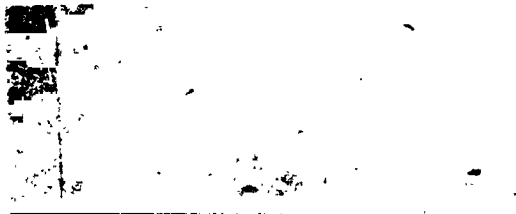
Effect of Laser Power on Laser-Metallized Linewidth After Rinsing the Silver Neodecanoate Film



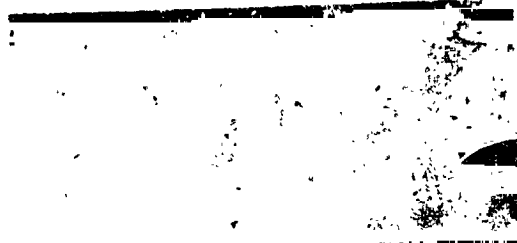
Maximum Power: 8.5 watts  
Width: 60  $\mu$ m



Maximum Power: 6.9 watts  
Width: 60  $\mu$ m



Maximum Power: 4.9 watts  
Width: 55  $\mu$ m



Maximum Power: 4.1 watts  
Width: 50  $\mu$ m

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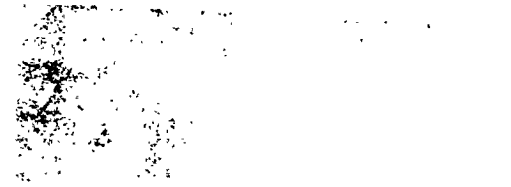
Effect of Laser Power on Laser-Metallized Linewidth After  
Rinsing the Silver Neodecanoate Film (Cont'd)



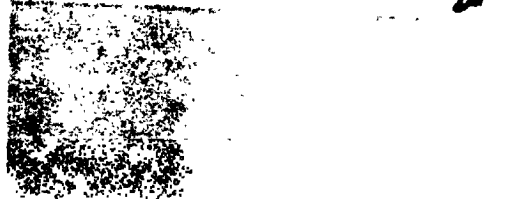
Maximum Power: 2.6 watts  
Width: 40  $\mu$ m



Maximum Power: 1.8 watts  
Width: 40  $\mu$ m



Maximum Power: 1.2 watts  
Width: 30  $\mu$ m



Maximum Power: 0.7 watt  
Width: 20  $\mu$ m



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Linewidths as a Function of Laser Power With 50 mm Lens  
Before and After Film Rinse

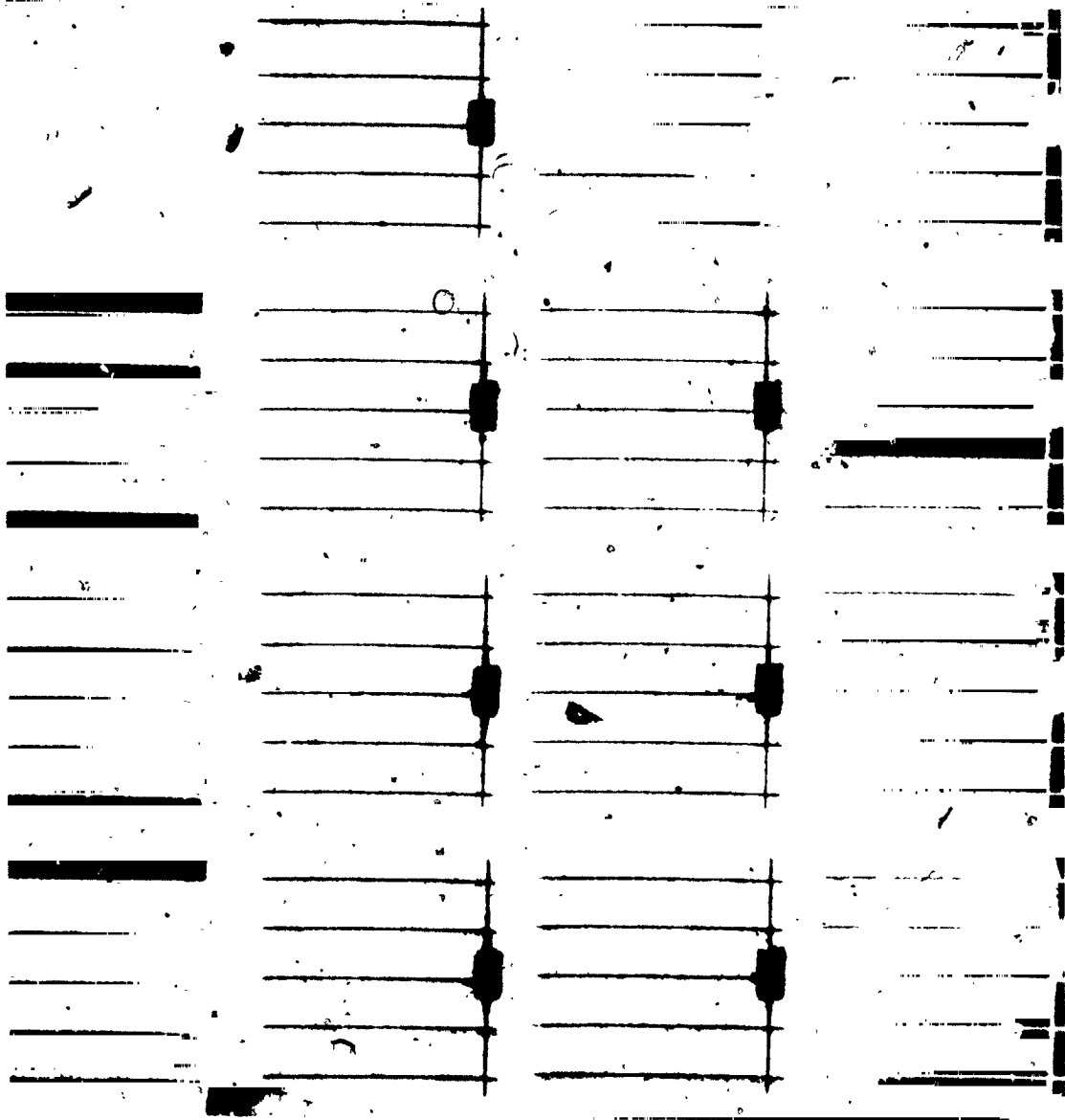
<u>Laser Power (W)</u>	<u>Before Film Rinse</u>	<u>After Film Rinse</u>
8.50	85 $\mu\text{m}$	60 $\mu\text{m}$
7.50	75	65
6.90	75	60
6.36	75	60
5.70	70	60
4.92	70	55
4.14	65	50
3.30	60	50
2.55	55	40
1.80	50	40
1.20	45	30
0.66	25	20

## PROCESSING

### Sequence of Laser-Assisted Maskless Metallization Process

- Evaporate 1500 Å Ti (adherence) and 500 Å Pd (cap) over entire Si wafer
- Spin solution of silver neodecanoate in xylene on wafer
- Write Ag lines (50 μm) with Ar<sup>+</sup> laser (8 W) at 20 cm/sec scan speed
- Dissolve undecomposed silver neodecanoate film in acetone
- Electroplate 8 μm Ag on laser-deposited Ag lines
- Etch Ti and Pd leaving only grid lines

Laser-Metallized Cells



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# PROCESSING

## Effect of Laser Power on the Performance of Cells Fabricated by Laser-Assisted Metallization Process

<u>Cell ID</u>	<u>Laser Power Watt</u>	<u>J<sub>sc</sub><sup>2</sup> (mA/cm<sup>2</sup>)</u>	<u>V<sub>oc</sub> (mV)</u>	<u>FF</u>	<u>η (%)</u>
1	8.5	33.5	577	.787	15.2
2	7.0	34.3	582	.792	15.9
3	6.0	34.6	579	.788	15.8
4	4.0	35.1	582	.781	16.0
5	3.0	34.9	582	.785	16.0
6	2.0	34.5	584	.786	15.9
7	1.0	34.1	573	.761	15.2



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Laser-Metallized Solar Cells on 4 ohm-cm Float-Zone Silicon  
After AR Coating

<u>Cell ID</u>	<u>J<sub>sc</sub><sup>sc</sup> (mA/cm<sup>2</sup>)</u>	<u>V<sub>oc</sub><sup>oc</sup> (mV)</u>	<u>FF</u>	<u>η (%)</u>
2	35.0	606	.754	16.0
3	34.9	603	.768	16.2
4	35.5	603	.750	16.0
5	34.8	601	.781	16.3
6	35.0	601	.779	16.4
7	35.4	603	.780	16.6
10	34.5	598	.778	16.1
11	33.8	604	.785	16.1
14	34.3	603	.789	16.3
15	34.2	604	.782	16.2
Q1+	35.1	609	.790	16.9

+Conventional Metallization/Lithography and no passivation

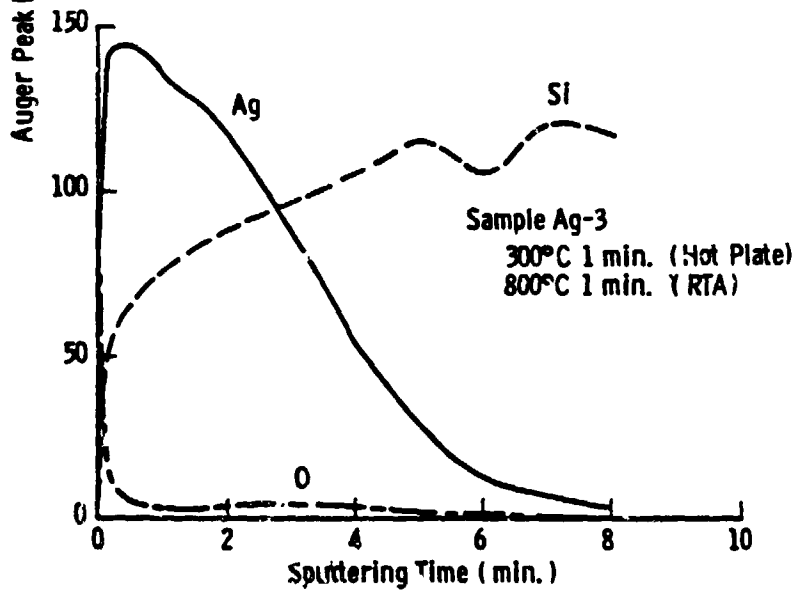
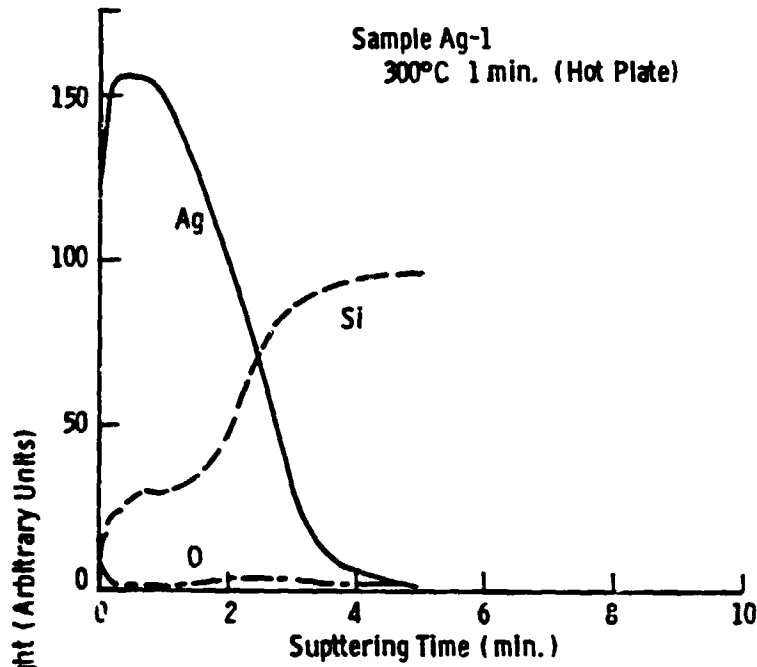


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A Comparison of Lighted and Dark I-V Data of 16.6% Laser-Metallized Cell and 18.4% Cell Fabricated by Conventional Metallization and Photolithography

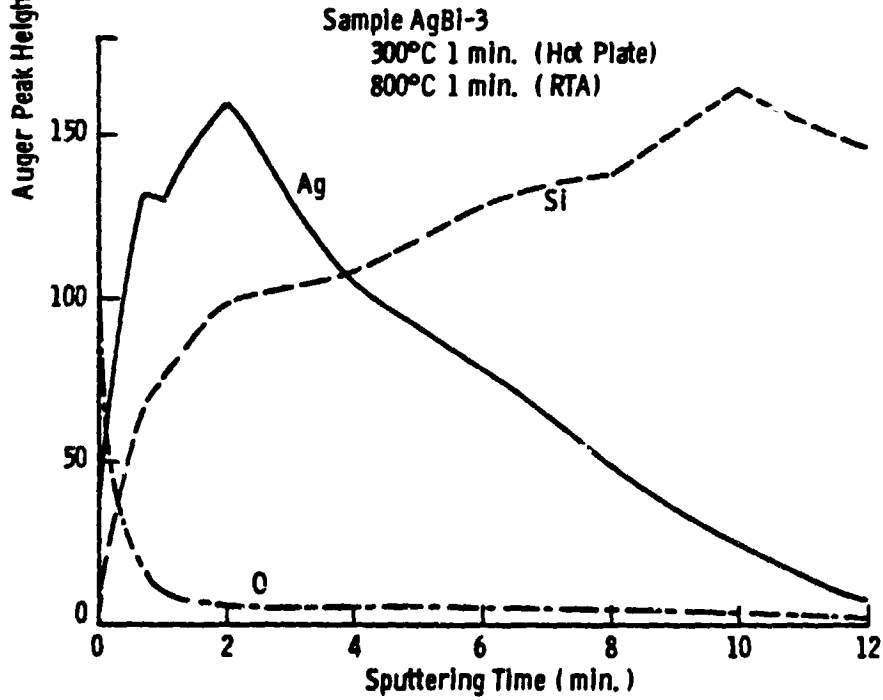
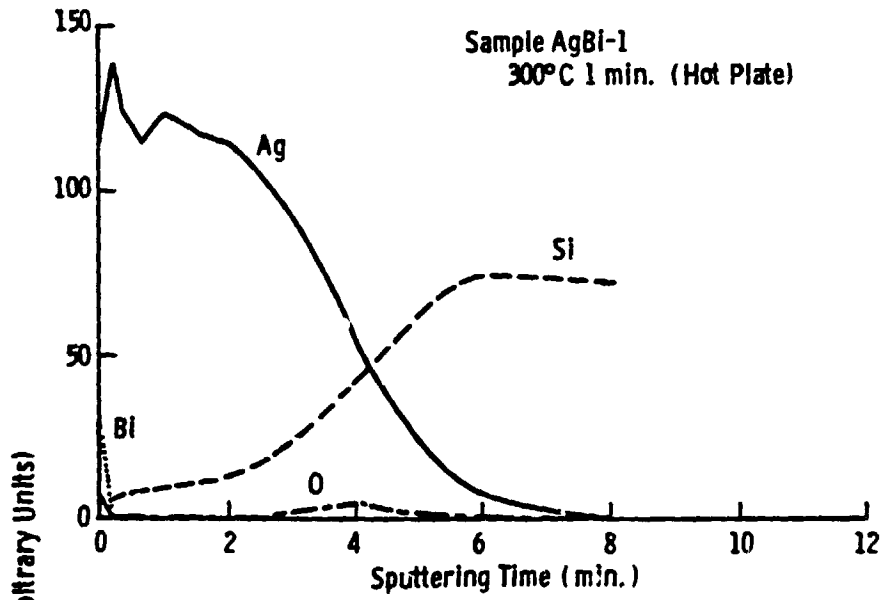
<u>Parameter</u>	<u>16.6% Laser-Metallized Cell</u>	<u>18.4% Oxide-Passivated Conventionally Metallized Cell</u>
$J_{sc}$	35.4 mA/cm <sup>2</sup>	36.7 mA/cm <sup>2</sup>
$V_{oc}$	604 mV	621 mV
FF	0.780	0.804
$\eta$	16.6%	18.4%
$R_s$	0.69 $\Omega$ -cm <sup>2</sup>	0.56 $\Omega$ -cm <sup>2</sup>
$R_{sh}$	103 k $\Omega$ -cm <sup>2</sup>	150 k $\Omega$ -cm <sup>2</sup>
$J_o$	$1.4 \times 10^{-12}$ A/cm <sup>2</sup>	$0.5 \times 10^{-12}$ A/cm <sup>2</sup>

Relationship of Auger Peak Height Versus Sputtering Time



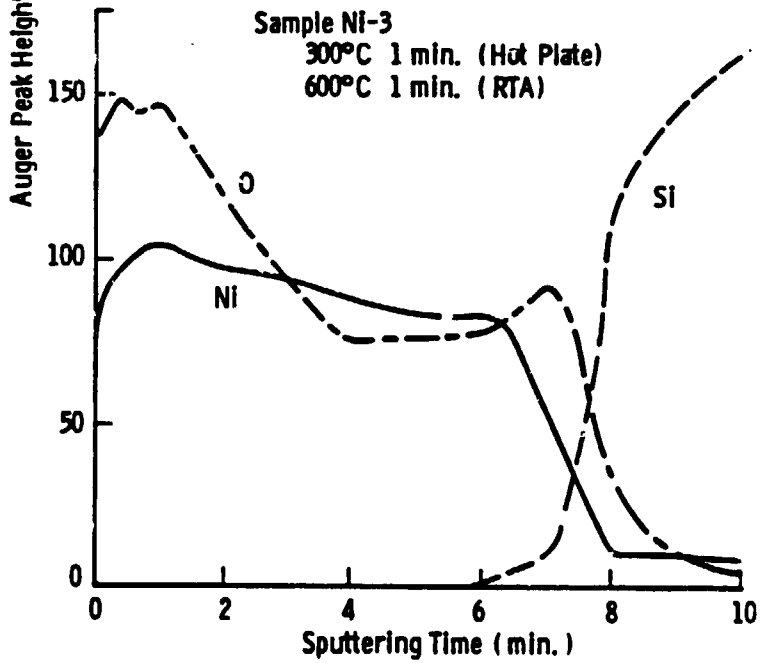
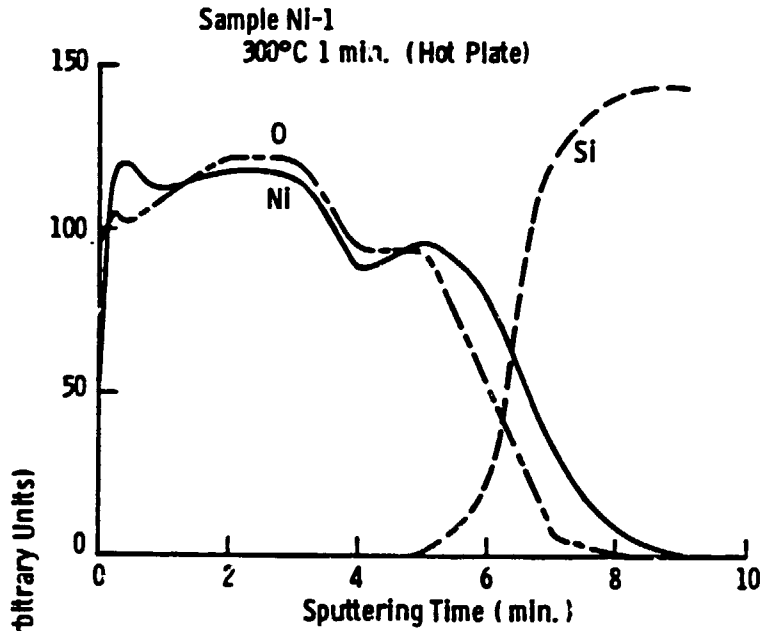
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Relationship of Auger Peak Height Versus Sputtering Time (Cont'd)



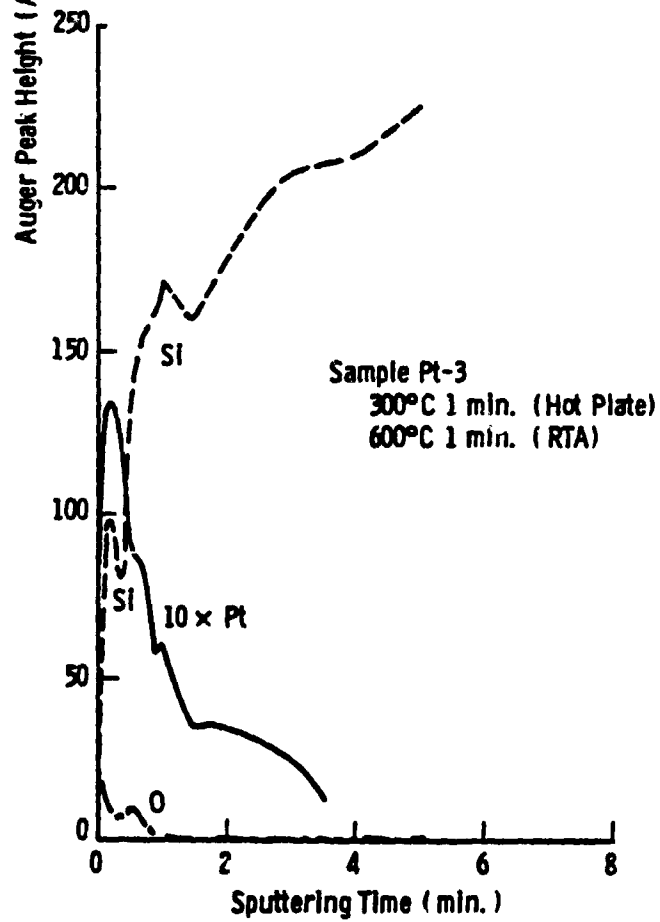
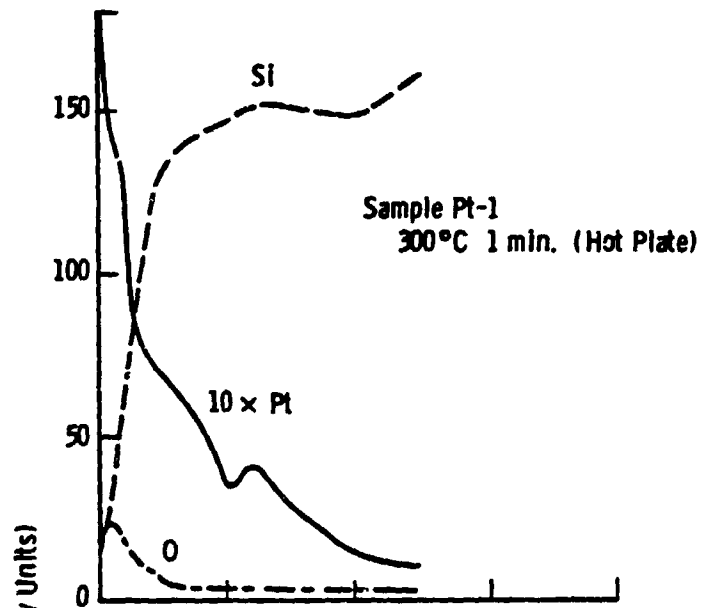
PROCESSING

Relationship of Auger Peak Height Versus Sputtering Time (Cont'd)



PROCESSING

Relationship of Auger Peak Height Versus Sputtering Time (Cont'd)



Summary

- **Linewidths of 20  $\mu\text{m}$  demonstrated**
- **Cells with efficiency up to 16.6% fabricated with a hybrid laser/evaporation maskless process**
- **Adherence of Ag to Si poor**
- **Alternative materials (Ag/Bi, Ni, Pt) also poorly adherent (preliminary result)**

