MEETING 17

finite element modelling

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ADVANCED LASER BASED MANUFACTURING

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Abstract

Laser crystallization of amorphous or microcrystalline silicon films to obtain high-quality polycrystalline films is one of the most promising methods for diminishing costs in the microelectronic and solar cells sectors. During a laser crystallization process light is partially absorbed by the amorphous silicon, heating the sample and, if the temperature rises high enough, causing the reorganization of the film structure into a crystalline one. In this work we show results on the crystallization of non-hydrogenated silicon thin-films by a continuous wave infrared laser, as well as a study of the process with a simple finite elements method (FEM) numerical model based in the dimensional non-linear heat transfer equation with a steady heat source.

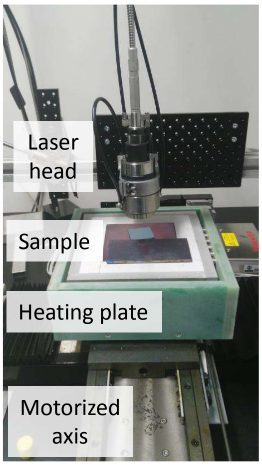
Results

Laser source and samples

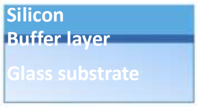
Laser source

- **Continuous wave** (CW) at **980 nm**
- **Linear spot**: 19,6mm (Top hat) x 2,16mm (Gaussian)

→ Allows the treatment of **large areas**



Samples *(IEEE Journal of Photovoltaics, Vol. 4, Nº. 6, November 2014)*



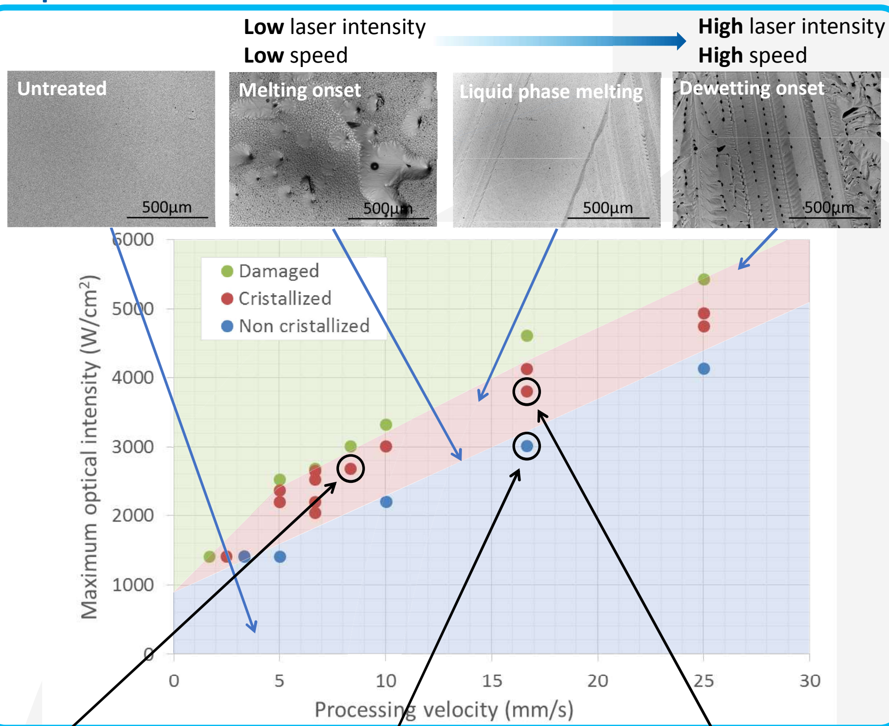
- Heat resistant substrate
- Buffer layer
- Heated to 700ºC

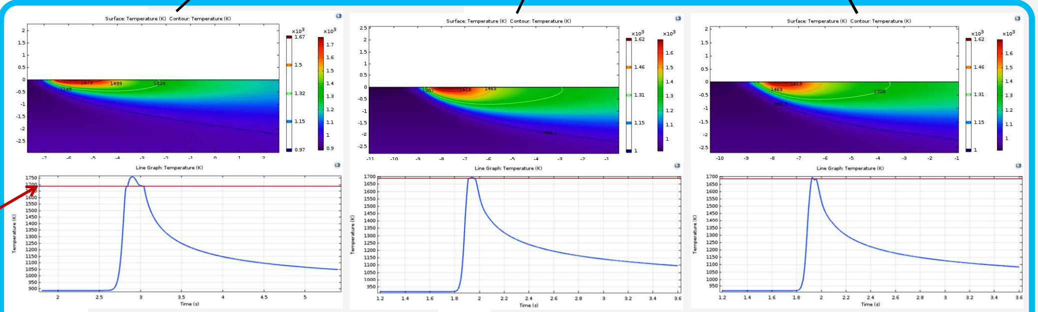
→ Prevent cracks by thermal stress

Process parameters:

- Power: **300 – 1300 W**
- Speed: **1 – 25 mm/s**

Experiments results



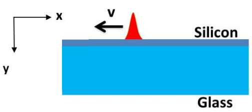


Results from the FEM model of the laser process with different process parameters.

FEM modelling

Finite Elements Method (FEM) model.

- 2D stationary model
  silicon film + glass substrate



- non-linear heat transfer equation
- Including phase change (1687 K)

Phase change	$\frac{1}{\sqrt{\pi}\Delta T}\exp\left(\frac{-(T-T_m)^2}{\Delta T^2}\right)$
Source term	$S(r,z,t) = P_i(r,t)[(1-R(T))\alpha(T)exp(-\alpha(T)\lvert z\rvert)]$
Fluence profile	$F(r) = F_P exp\left[-2\left(\frac{r}{r_w}\right)^2\right]$

FEM model results

- **Good agreement** between calculations and experiments.
- Irradiation time is **a key variable** in the crystallization process.
- The model → **can predict the start** of the liquid phase crystallization process
  → can be used to study the **onset of the dewetting** of the silicon.

Conclusions

- A **continuous wave IR laser** source emitting at 980 nm has been used to crystallize amorphous silicon (a-Si) thin films.
  - Laser-annealed films with high crystalline quality (**grains of several mm long**) have been obtained.
- A simple thermal FEM model has been developed in COMSOL Multiphysics to simulate the process by numerically solving the two dimensional non-linear heat transfer equation with a steady heat source.
  - The local temperature evolution in the irradiated area given by the FEM model shows **good agreement with the experiment results**.
  - The model helps to determine the experimental parameters needed for crystallizing a-Si without damaging the film.

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