Microcrystalline Silicon Solar Cells Deposited from $SiF_4/H_2/Ar$ Gas Mixtures

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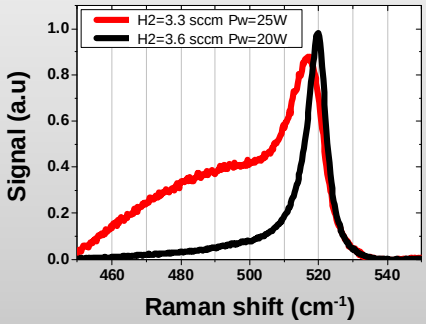
Introduction

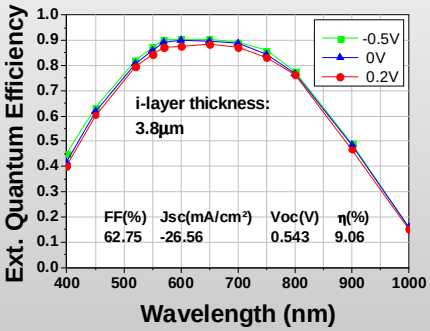
The fabrication of silicon simple PIN junction solar cells **typically** uses deposition plasmas made of **SiH_4/H_2** for the microcrystalline silicon intrinsic layer. The deposition of such optimized layers requires a **high H_2 dilution** (SiH_4/H_2~0,04) and a **crystalline fraction between 50% and 70%**. The presence of at least 30% of amorphous fraction leads to the Light Induced Degradation (LID) phenomenon.

The (lab) world record is **10,9%** [1] with advanced optimization of interfaces and of materials. **Thickness of the i-layer is limiting**: performance drops with too thick layers (>2,2µm).
We propose [2] to use **SiF_4/H_2/Ar plasma** at **high pressure** with a high argon flux and a ratio of SiF_4/H_2~1. We aim for an understanding of the deposition process and an optimization of the material deposited from this plasma chemistry.

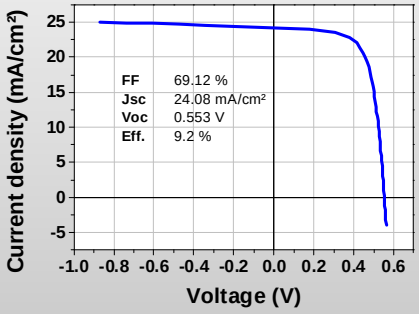
Cells Properties



- X_c controlled by H_2 flow and Power
- Layer fully crystallized
- No LID
- Correlation length ~5nm (FWHM @ 520)

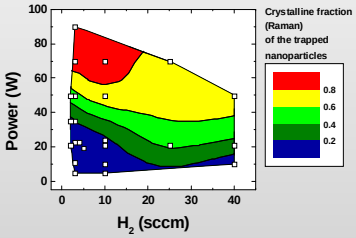


- Good collection properties
- Thick layer of 3.8µm
- Even for λ>800nm
- Forward/Reverse ratio >95%

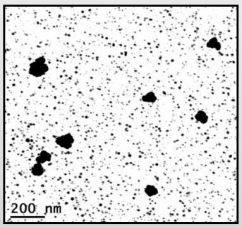


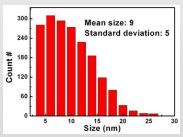
- Efficiency of 9.2% achieved
- V_{OC}>535mV (EPFL-IMT [1]) with X_c~1 !
- No sophisticated optimization
- Vacuum break between each layer

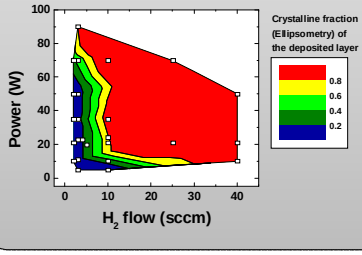
Growth Mechanism

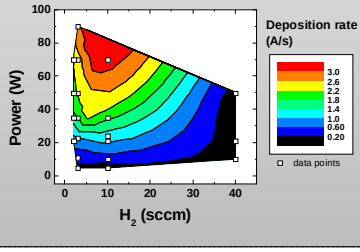


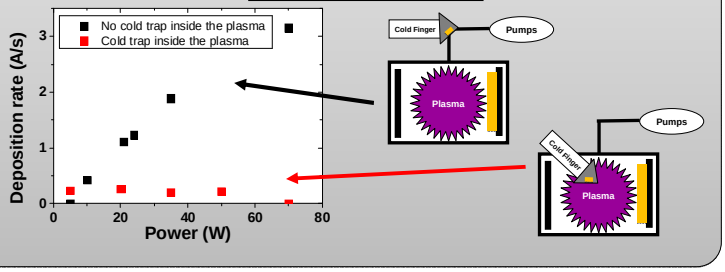
Growth hypothesis: nanocrystal precursors:
- Powder trapping by cold finger (thermophoresis)
- Crystalline fraction study (powder/layer)
- Deposition rate deduced from ellipsometry
- Visualization of nanocrystals by TEM imaging











Prospects

- Cell fabrication transferred to Cluster-PECVD (depositions without vacuum break)
- Optimization: plasma parameters, layer thicknesses, texturing…

} Goal: exceed 10% efficiency

- Study for a deeper understanding of role of nanocrystals (use of mass spectrometer for instance)
- Evaluation of gas consumption and increase of deposition rate

[1] Hanni *et al.*, IEEE Journal of Photovoltaics, DOI 10.1109/JPHOTOV.2012.2214766
[2] Dornstetter *et al.*, IEEE Journal of Photovoltaics, DOI 10.1109/JPHOTOV.2012.2221683

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