Old vision: The fabrication of single junction PIN solar cells typically uses Si:H/H2 plasmas for the deposition of the microcrystalline silicon intrinsic layer. The deposition of such optimized layers requires a high H2 dilution and a crystalline fraction between 50% and 70%.

New vision: we have demonstrated that SiF4/H2/Ar plasmas at high pressure with a high argon flow and a low H2 dilution (SiF4/H2=1) lead to fully crystallized layers. Despite of that we can produce microcrystalline material of high quality for solar cell application. Thanks to plasma diagnostics and modeling we have provided a better understanding of the growth mechanisms.

**Plasma studies**

- **H2 flow rate series**: the key parameter to tune the a-Si:H/µc-Si:H transition
- Why amorphous: H2 flow rate (scm) D, p-D, H2, CH2, CH3
- Why microcrystalline: H2 flow rate (scm) CH, CH2, CH3

**Phenomenological model**

\[ \text{SiF}_4 \rightleftharpoons \text{SiF}_2 + F \]
\[ \text{H}_2 \rightleftharpoons 2\text{H} \]
\[ \text{H} + F \rightleftharpoons \text{HF} + \text{H} \]

The plasma physics is simplified into three equations: the dissociation of SiF4 and H2, and the formation of HF, which is the main feature of SiF4 compared to SiH4. There are two regimes:
- F-limited regime: HF is formed until all F atoms are used. There is not enough hydrogen to crystallize the layer (amorphous).
- H2-limited regime: HF is formed until all hydrogen is consumed. There is not enough hydrogen to crystallize the layer (amorphous).

We develop a simple yet accurate model to account for that!

**Nanoparticles**

Beyond the simple phenomenological model, the fact is that our plasmas are dusty. Plasma-generated nanoparticles (NP) influence the deposition as they can be amorphous (a-NP) or crystalline (c-NP).

**Material studies**

- **SIMS**
  - Profile over PIN solar cell:
  - \( [\text{H}] = 4\% \)  \( [\text{F}] = 0.1\% \)

- **Hydrogen effusion**
  - H2 effusion shows weakly and tightly bonded hydrogen. The ratio increases with the H2 flow rate. The H concentration drops by a factor 2 at the transition.
  - Absorption at 80.8eV is used to estimate the defect density. Achievement: \( q_{\text{SiH}} \approx 3 \times 10^{14} \text{ cm}^{-3} \)
  - \( \leftrightarrow 5.1 \times 10^{14} \text{ cm}^{-3} \) defect density

**Devices**

- **Solar cell structure**
  - We aimed at several um-thick fully crystallized I-layers.

**Conclusions & Perspectives**

The new questions are:
- Can we go below 5x10^{14} cm^{-3} in defect density?
- How large can be the crystallites?
- Can we deposit a-Si:H with lower hydrogen content?
- Can we grow better epi-Si than with SiH4?

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